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**BULLETIN OF ANIMAL HEALTH AND PRODUCTION IN AFRICA**

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# IMAGERIE ECHOGRAPHIQUE DU DEVELOPPEMENT EMBRYONNAIRE CHEZ LA CHEVRE DU SAHEL

Boureima Traore[1]*, Moussa Zongo[1], Auguste T. Yamboue[1], Moussa Kimse[2], Were Pitala[3] et Drissa S. Sanou[1]

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## Résumé

Les caractéristiques du développement de l'embryon de la chèvre ont été appréciées par observations échographiques en zone soudano-sahélienne du Burkina Faso. L'étude a concerné dix-huit (n=18) chèvres du sahel d'âge, de poids et de parité respectifs compris dans les intervalles [24 - 36] mois, [30 - 40] Kg et [1– 4]. Les examens ont été pratiqués deux fois par semaine au moyen d'une sonde de 5 Mhz par la voie transrectale entre les jours 18 et 60 après les saillies.

Le délai moyen pour un diagnostic précoce de gestation chez la chèvre du sahel est de 23,80 ± 3,76 jours avec des variations entre les primipares et les multipares. La fenêtre optimale pour le diagnostic précoce de gestation a été l'intervalle [21 -30] jours. Les observations échographiques de la gestation ont montré l'apparition d'une vésicule embryonnaire de diamètre 9,42 ± 1,01 mm remplie d'un liquide contenant un filament lumineux de longueur 7,37 ± 1,05 mm à J21.

La chronologie du développement embryonnaire a été marquée par des évènements majeurs. En effet, la symétrisation et la métamérisation de l'embryon ont été observées à J24 avec l'apparition des ébauches de la tête, des membres et du corps. Les battements cardiaques et le cordon ombilical ont été observés à J28. L'ossification de la voûte crânienne avec la délimitation des orbites ont été observés J40. A partir J45 de gestation, les membres, la tête, la queue, le cordon ombilical et le corps sont bien individualisés et les fœtus effectuent des mouvements de pattes.

Les données de cette étude sont de précieux guides aux producteurs et aux techniciens dans la conduite des troupeaux caprins notamment pour le diagnostic de gestation, le suivi de la croissance fœtale, l'estimation de la date de parturition, la détection des pseudo-gestations et la détection des retards de croissance fœtale.

**Mots clés :** échographie, embryon, placentômes, cordon ombilical, gestation, chèvre du Sahel.

# ULTRASONOGRAPHIC IMAGING OF EMBRYONIC GROWTH IN SAHEL GOAT

## Abstract

The means times of early pregnancy diagnosis establishment by ultrasonography were 23.80 ± 3.76 days after fertilization with variation between primiparous females and multiparous. The best period for early pregnancy diagnosis in this experiment was included in interval [21-30] days. Embryonic vesicle with a diameter of 9.42 ± 1.01 mm containing a filamentous and luminescent embryo of length 7.37 ± 1.05 mm was observed at day 21.

The chronology of embryonic development was marked by the major events. Indeed, symmetrization and metamerization of the embryo were observed on D24 with the appearance of the sketches of the head, limbs and body. Heartbeats were detected and umbilical cord was observed at day 28. The ossification of the skull-roof and the delimitation of the orbits were observed J40. At day 45, the limbs, head, tail, umbilical cord and body were very individualized and the fetus performs leg movements.

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The data in this study are valuable guides to producers and technicians in managing goat herds such as for pregnancy diagnosis, fetal growth monitoring, estimating parturition date, pseudogestation detection and detection fetal growth retardation.

**Key Words:** ultrasound, Embryonic development, Placentôme, Umbilical Cord, Sahelian goat

## Introduction

Ces dernières années ont connu un renouveau des travaux sur les caprins. Dubeuf (2011) et Rege *et al*., (2011) soulignent l'intérêt pour la recherche de soutenir ce secteur d'activité agricole, notamment dans les régions où les perspectives de développement de l'élevage caprin semblent favorables.

La chèvre du sahel, à cause de son cycle court et continue et de son format est mieux adaptée aux capacités d'investissement des familles modestes et constitue la principale source de protéines animales (viande, lait et ses dérivés) et de revenus pour les populations rurales (Zongo *et al*., 2009 ; Nantoumé *et al*., 2011).

Cette espèce développe cependant de nombreuses contraintes de reproduction dont la fréquence moyenne de pseudogestation s'élève de 3 à 4 %, voire 20% (Zarrouk *et al*., 1999). L'application de techniques de diagnostic précoce de gestation et de suivi du développement fœtal revêt une valeur ajoutée considérable pour optimiser le taux de survie des nouveaux nés et améliorer le revenu des producteurs. L'échographie permet de détecter les femelles gestantes, d'évaluer la viabilité embryonnaire et de compter le nombre de fœtus par gestation (Zongo *et al*., 2014).

Dans les élevages tropicaux où les mâles et les femelles sont conduits ensemble, cette technique est un atout important pour une gestion optimale de la reproduction. Elle fournit aux producteurs, les informations nécessaires pour regrouper les femelles gestantes selon leur besoin nutritionnel et organiser un rationnement approprié au cours du dernier trimestre de la gestation, réaliser le tarissement à des périodes adéquates et les préparer à la parturition (Vural *et al*., 2008).

L'application de l'échographie à la reproduction de la chèvre est encore récente et a porté sur la validation de la technique, le développement folliculaire et sur l'involution utérine au cours du postpartum (Zongo *et al*., 2014 ; Zongo *et al*., 2015). L'identification des femelles gestantes et le suivi du développement embryonnaire n'ont pas suffisamment été développés.

L'objectif de la présente étude est de déterminer les caractéristiques d'un diagnostic précoce de gestation et de rapporter les images de la chronologie des séquences de développement embryonnaires chez la chèvre du sahel.

## Materiel et Methodes

*Animaux et traitements*

L'étude a été réalisée à la station expérimentale de l'Université Ouaga I Professeur Joseph KI-ZERBO. Elle a concerné dix-huit (n=18) chèvres d'âge, de poids et de parité respectifs compris dans les intervalles [24 - 36] mois, [30 - 40] Kg et [1– 4]. Toutes les femelles ont été induites en œstrus et saillies par cinq (05) boucs fertiles de la station expérimentale. Un diagnostic précoce de gestation a ensuite été réalisé à partir de dix-huit jours (J18) après la saillie par échographie. Le jour de la saillie est considéré comme le jour zéro (J0) de la gestation (Karen *et al*., 2014).

*Examens échographiques*

Les observations échographiques ont été pratiquées deux fois par semaine (Karen *et al*., 2014) du jour dix-huit (J18) au jour soixante (J60) après les saillies. Les femelles ont été maintenues en station débout dans un couloir de contention. Le diagnostic de gestation et les examens de l'embryon ont été réalisés par voie transrectale au moyen d'une sonde linéaire de 5 MHz. Le câble de raccordement de la sonde a été rigidifié avec un manchon de tube caoutchouc afin de faciliter son introduction

et sa manipulation dans le rectum de l'animal. La sonde a été enduite d'un gel, avant tout examen. Les critères d'un diagnostic précoce de gestation sont ceux rapportés par Padilla-Rivas *et al*., (2005) et Karen *et al*., (2014).

Les images des séquences du développement embryonnaire ont été enregistrées et commentées tout au long de l'expérimentation.

*Analyses statistiques*

Les résultats collectés ont été rangés en moyenne plus ou moins écart-type et analysés au moyen du test t de student avec le logiciel GraphPad Prism 5.3. Les différences ont été considérées comme significatives au seuil de probabilité de 5% ($p<0,05$). Les images échographiques ont été traitées à l'aide de Paint de MS Office 2016.

## Résultats et Discussion

*Résultats*

*Diagnostic précoce de gestation*

Le délai moyen pour un diagnostic précoce de gestation chez la chèvre du sahel est de 23,80 ± 3,76 jours. Pour l'ensemble des femelles de l'expérimentation, les diagnostics précoces de gestation ont été réalisés dans l'intervalle [21 - 30] jours. Toutefois, 75 % des diagnostics précoces de gestation ont été pratiqués à J24. Le délai moyen de diagnostic de gestation a varié selon la parité de la femelle. Chez les femelles primipares, le diagnostic de gestation semble plus précoce comparativement aux femelles multipares. Les délais moyens de diagnostic précoce de gestation ont été de 21,2 ± 1,83 jours chez les primipares. Chez les femelles multipares, ce délai a été 25,41 ± 2,75 jours. La différence de variation entre les délais moyens de diagnostic précoce de gestation chez les primipares et multipares a été significative ($p = 0,04$). Les observations échographiques de la gestation ont montré une augmentation du diamètre de la corne gestante et la présence de vésicules embryonnaires (Figure 1A). De J24 à J30, les diamètres moyens de la corne gestante sont passés de 27,53 ± 2,76 millimètres à 33,73 ± 5,20 millimètres.

*Développement embryonnaire*

*La vésicule embryonnaire ou sac embryonnaire*

A partir du jour 21 jusqu'au jour 23 après les saillies, les observations échographiques ont rapporté l'apparition d'une vésicule remplie d'un liquide contenant un filament lumineux en son centre (Figure 1A). Ces observations ont été rapportées chez huit (n=8) femelles à J21 et chez six (n=6) autres femelles aux jours 23 et 24 après les saillies. Le diamètre de la vésicule embryonnaire a été 9,42 ± 1,01 mm et la longueur du filament lumineux a été 7,37 ± 1,05 mm à J21.

*Bouton embryonnaire*

Par la suite (J24), le filament lumineux s'est étalé et épaissi à l'intérieur de la vésicule liquidienne (Figure 1B). De J24 à J29, les images échographiques ont montré un embryon arrondi à ovale avec dans la partie médiane une ligne de symétrisation et au pourtour une métamérisation apparente. Le cordon ombilical est apparu à J28 et a mesuré 2,91 ± 0,94 mm. J28 est également la date où les battements cardiaques sont perceptibles pour la première fois (Figure 1C).

A partir de J30, les observations ont montré une image d'un embryon complet chez toutes les femelles de l'expérimentation. La longueur moyenne de l'embryon à cette date est de 10,29 ± 1,53 mm. A cette date, les observations échographiques ont montré l'image d'un embryon recourbé avec l'apparition de la membrane amniotique. Aussi, la tête et le cœur sont individualisés et visibles (Figure 1D).

A J36, la cavité abdominale de l'embryon a été visible sur les images échographiques, les ébauches des pattes ont été apparentes, le cordon ombilical et la queue se dessinent aisément (Figure 2A).

Les placentômes ont été observés à J40 sous forme de nodules ovales et éclaircies sur la paroi utérine (figure 2B). A cette date, le diamètre moyen des placentômes a été 7,23 ± 1,1 mm.

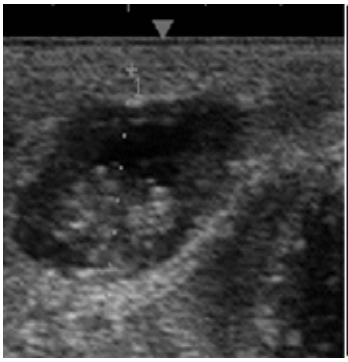
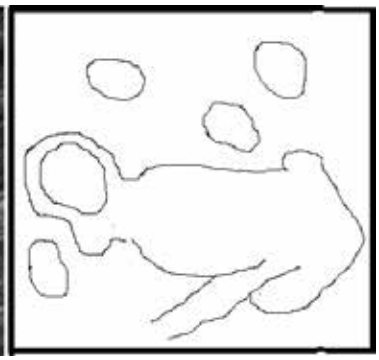
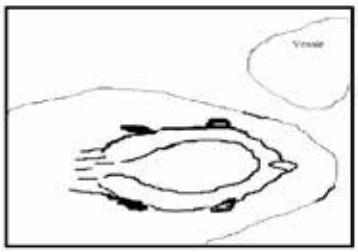
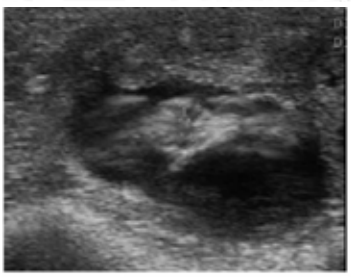
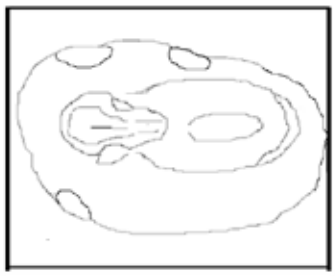
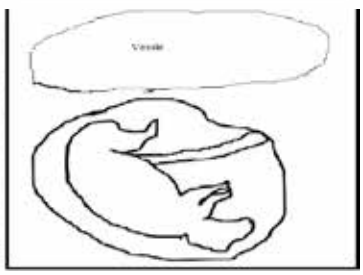
| **Images échographiques** | **Représentations schématiques** | **Commentaires** |
|---|---|---|
|  |  | • Embryon en forme de « L » et libre,<br>• Cavitéabdominaleformée,<br>• Apparition des pattes, la queue et les cotylédons<br>2A :Jour 36 (J36) |
|  |  | • Crâne délimité et le pariétal est visible<br>• Apparition des placentômes<br>• Cordon bien individualisé<br>2 B : Jour 40 (J40) |
|  |  | Vue ventrale du fœtus de 42 jours<br>• Membres visibles<br>• Queue se dessine |
|  |  | |
|  |  | Vue de profile du fœtus de 48 jours<br>• Membres antérieurs et postérieurs<br>• Cordon ombilical<br>• Tête |

**Figure 1 :** Chronologie du développement embryonnaire au cours du premier mois.

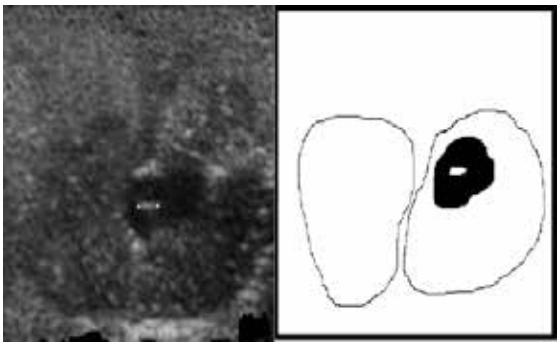
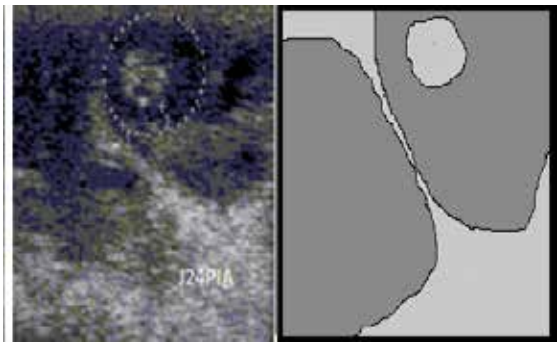
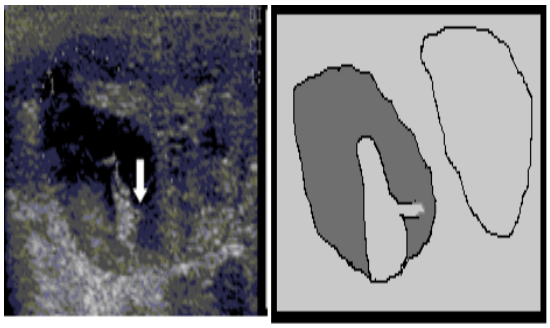
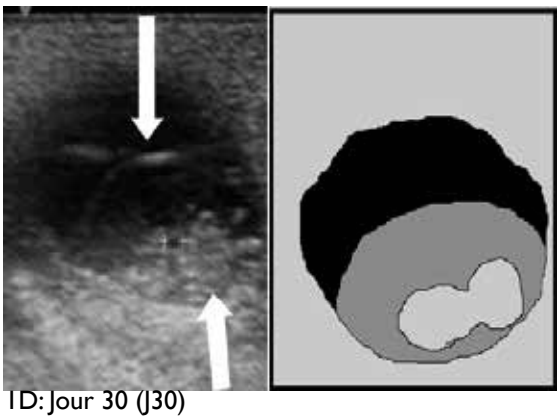
| Images échographiques | Représentations schématiques | Commentaires |
|---|---|---|
|  1A: Jour 21 (J21) | | • Cornes utérines dissymétriques<br>• Vésicule sombre avec un embryon filamenteux |
|  1B :Jour 24 (J24) | | • Stade bouton embryonnaire avec embryon segmenté<br>• Observation des ébauches des pattes, de la tête et du corps. |
|  1C: Jour 28 (J28) | | • Embryon<br>• Corne utérine vide<br>• Apparition du cordon<br>• Début battement cardiaque |
|  1D: Jour 30 (J30) | | • Apparition membrane amniotique<br>• tête individualisée<br>• Cœur |

**Figure 2 :** chronologie du développement embryonnaire entre J36 et J48

A J42, la face ventrale de l'embryon a été examinée. L'image a montré que l'abdomen, la tête, les membres antérieurs et postérieurs et la queue sont nettement visibles (Figure 2C). Les figures 1 et 2 rapportent les images échographiques du développement chronologique de l'embryon et de ses annexes.

## Discussion

Cette expérimentation a rapporté les résultats des examens échographiques de diagnostic précoce de gestation et du développement de l'embryon chez la chèvre du sahel au cours des 60 premiers jours de gestation. Les représentations schématiques et l'analyse des observations échographiques ont permis de décrire les caractéristiques d'un développement embryonnaire précoce et tardif. Ces résultats sont complémentaires des données rapportées par Sivachelvan *et al*., (1996) et par Waziri *et al*., (2012) sur les observations post-mortem des fœtus de chèvres.

La fenêtre optimale pour le diagnostic précoce de gestation chez les femelles de notre expérimentation a été l'intervalle [21 -30] jours. Cet intervalle correspond aux fourchettes de [24 – 29] et de [21 – 50] jours rapportées respectivement par Karen *et al*., (2014) et par Raja-Khalif *et al*., (2014) sur les chèvres Baladi et Boer.

Les observations échographiques ont montré que le début de gestation chez la chèvre du sahel a été caractérisé par une augmentation du diamètre de la corne gestante et la présence d'une vésicule sombre contenant un embryon filamenteux. Des observations similaires ont été rapportées chez les ovins de la race Alpine par Doize *et al*., (1997). L'aspect filamenteux de l'embryon résulterait du processus d'élongation du blastocyste juste avant son implantation (Suguna *et al*., 2008). Le délai d'apparition de cette observation a varié en fonction de la parité des femelles. Elle a été observée précocement chez les femelles primipares et tardivement chez les femelles multipares ($P<0,05$). Cette différence serait liée à une modification anatomo-morphologique de l'appareil génital sous la pression des gestations antérieures qui plonge l'utérus dans la cavité abdominale. De même, certains auteurs ont rapporté que la sensibilité de la technique échographique appliquée au diagnostic de gestation était plus élevée chez les jeunes que les vieilles brebis (Karen *et al*., 2004) et les chèvres (Karen *et al*., 2014). Ce facteur de variation disparaît avec la mise à jeun des animaux ou le soulèvement de l'abdomen (Karen *et al*., 2014).

Les caractéristiques de l'embryon observées à J24 chez la chèvre du sahel ont été rapportées par Medan *et al*., (2004). Cette forme discontinue de l'embryon traduirait une métamérisation et une symétrisation apparente assimilable à l'organisation du corps, aux ébauches des membres et de la tête. Dans la présente étude, les battements cardiaques ont été observés à J28. La littérature sur les races caprines d'Europe et d'Asie a rapporté l'observation des battements cardiaques entre les jours 19 et 28 de gestation (Medan *et al*., 2004, Padilla-Rivas *et al*., 2005 ; Suguna *et al*., 2008). Bien que les battements du cœur soient perceptibles, les différentes cavités du cœur ne sont pas nettement observables. Suguna *et al*., (2008) ont rapporté des observations similaires. Le cordon ombilical a été observé à J28 avec un diamètre moyen de 2,91 ± 0,94 mm. Des observations similaires ont été rapportées par Kandiel *et al*., (2015) chez les chèvres Shiba. Le cordon ombilical a une structure anatomique particulière qui le rend facilement observable à l'échographie. A J30, l'embryon est détaché de la paroi de l'utérus et la membrane amniotique est bien individualisée. Des observations similaires ont été rapportées par Airina *et al*., (2011) chez la chèvre. Par ailleurs, l'embryon présente une forme recourbée qui pourrait s'expliquer par l'individualisation de la tête. La tête individualisée et différenciée du reste du corps par un étranglement a été observée à partir de J30. Chez les brebis, Valasi *et al*., (2016) ont rapporté que la tête et le tronc s'individualisent vers le J31.

Les placentômes ont été observées dans l'intervalle [36 – 42] jours de gestation avec un diamètre moyen de 7,23 ± 1,1 mm.

Ces observations ont été inclues dans la fourchette de 34 à 42 jours de gestation déjà rapportée chez la chèvres (Kandiel *et al*., 2015 ; Medan *et al*., 2004 ; Suguna *et al*., 2008) et la brebis (Jones *et al*., 2016; Ali et Hayder, 2007). Les caractéristiques morphologiques des placentômes décrites par échographie sont celles des observations visuelles directes après l'abattage (Igwebuike et Ezeasor, 2013). Les placentômes résultent de l'interdigitation entre les cotylédons avec les caroncules utérines afin de faciliter les échanges fœto-maternelles (Igwebuike et Ezeasor, 2013 ; Martinez *et al*., 1998).

L'observation du crâne avec la délimitation des orbites a laissé penser que l'ossification de l'embryon a commencé par la formation de la voûte crânienne ou calvarium à partir du jour 42 (Sivachelvan *et al*., 1996). A cette période, l'individualisation des membres et des oreilles ont été observées à l'échographie. De plus, des mouvements de faibles amplitudes ont été observés. Des observations similaires ont été rapportées chez les ovins (Ali et Hayder, 2007; Jones *et al*., 2016 ;Valasi *et al*., 2016).

D'une manière générale, les observations échographiques de notre étude complètent les observations post-mortem décrites chez les chèvres (Sivachelvan *et al*., 1996; Waziri *et al*., 2012). La chronologie du développement des organes embryonnaires dans l'intervalle de nos observations correspond aux résultats rapportés par Sivachelvan *et al*., (1996) et Valasi *et al*., (2016).

## Conclusion

Ce travail a rapporté les images échographiques d'un diagnostic précoce de gestation et du développement embryonnaire chez la chèvre du Sahel. L'analyse des images a permis de décrire les caractéristiques d'une gestation précoce et du développement embryonnaire chez la chèvre. Les données obtenues dans cette étude, constituent des valeurs de référence pour le contrôle du développement intra-utérin de plusieurs paramètres de l'embryon de chèvre. Elles servent en outre, de précieux guides aux producteurs et aux techniciens dans la conduite des troupeaux caprins notamment pour le diagnostic de gestation, le suivi de la croissance fœtale, l'estimation de la date de parturition, la détection des pseudo-gestations et la détection des retards de croissance fœtale.

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# FACTEURS MENAÇANT LA SURVIE D'APIS MELLIFERA ADAMSONII LATREILLE 1804 (HYMENOPTERA, APIDAE) ET LA PRODUCTION DE MIEL AU SÉNÉGAL

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## Résumé:

Au Sénégal, l'apiculture est une activité menée par 85% des agriculteurs. Or en 2012, la disparition spectaculaire des abeilles notifiée dans le monde avait aussi marqué l'apiculture sénégalaise.

Ainsi, cette étude menée entre Septembre 2014 et janvier 2016 au Sénégal avait pour objectif d'évaluer la production de miel dans quatre zones agroécologiques du pays de 2011 à 2014 et d'identifier les facteurs qui entravent cette production et menacent la survie des abeilles.

Les enquêtes ont été menées auprès de 138 apiculteurs individuels et 32 associations d'apiculteurs répartis dans quatre zones apicoles. Les logiciels Epi-Info 3.5.4; STATA 9.0 et Excel ont permis le traitement et l'analyse des données récoltées.

Il en ressort que la production de miel était statistiquement différente entre les sites en 2011, 2012 et 2014 (P= 0,0007 ; 0,0016 et 0,034 respectivement) contrairement en 2013 (p>0,05). Par ailleurs, cette différence de production n'était pas significative à l'intérieur des sites entre les années et ne dépendait pas du nombre de ruches. Les apiculteurs ont attribué cette baisse de production à 79%, 65%, 33% et 68% aux prédateurs des abeilles respectivement à Toubacouta, Bandia/village, zone des Niayes et Vélingara suivi des facteurs environnementaux (20%) et activités humaines (15%). La majorité des apiculteurs (52%) avait été victime du phénomène de désertion des colonies des ruches.

Il en ressortait que, la production du miel entre les sites variait significativement et le phénomène de disparition des colonies restent un défit important auquel sont confronté les apiculteurs Sénégalais. Cette étude fournit également des informations de base pour de futures études.

**Mots-clés:** Abeilles, désertion, production miel, Sénégal,

# FACTORS THREATENING HONEYBEE APIS MELLIFERA ADAMSONII LATREILLE 1804 (HYMENOPTERA, APIDAE) SURVIVAL AND HONEY PRODUCTION IN SENEGAL

## Abstract:

In Senegal, beekeeping is conducted by 85% of farmers but in 2012, the spectacular observation of disappearance of bees around the world was also observed by Senegalese beekeepers.

This study conducted between September 2014 and January 2016 in Senegal aimed to evaluate the honey production in four agroecological zones of the country from 2011 to 2014 and to identify factors that hinder its production.

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138 individual beekeepers and 32 beekeepers associations in four beekeeping areas were surveyed using a structured questionnaire. The Epi-Info 3.5.4; STATA 9.0 and Excel softwares were use used to process and analyze collected data.

Honey production was statistically different between sites in 2011, 2012 and 2014 (P = 0.0007, 0.0016 and 0.034 respectively), unlike in 2013 (p> 0.05). Moreover, this difference in production was not significant within sites between those years. Beekeepers attributed the decrease in production at 79%, 65%, 33% and 68% to bee predators respectively in Toubacouta, Bandia / village, Niayes zone and Vélingara followed by environmental factors (20%) and human activities (15%). Most of the beekeepers (52%) were victims of colony collapse disorder (CDD).

This study revealed that honey production between sites varied significantly and the phenomenon of colony collapse disorder or colony disappearance remains an important challenge faced by Senegalese beekeepers.

**Keywords:** Bees, disappearance, honey production, Senegal

## Introduction

L'agriculture représente près de 80% des exploitations agricoles en Afrique sub-saharienne et emploie 75% des actifs (Hauchart, 2007). La proportion moyenne des plantes qui dépendent directement de la pollinisation est estimée à 94% dans les zones tropicales et 78% dans les zones tempérées (Ollerton, 2011). L'étude menée par Klein (2007) a montré que la production de fruits, de légumes ou de graines de 87% des principales cultures vivrières mondiales dépend de la pollinisation animale; et sur 107 cultures, 35 dépendent de la pollinisation directe par les abeilles (domestiques et/ou sauvages). Ainsi, l'apiculture constitue un secteur important de l'économie rurale, tant par le rôle joué par les populations d'abeilles dans la sécurité alimentaire grâce à la pollinisation que par la génération de revenues et création d'emploies par la transformation de produits et sous- produits de la ruche.

En outre, l'abeille constitue un excellent indicateur biologique et intervient comme sentinelle en donnant l'alerte pour les atteintes à l'environnement et à la biodiversité (Celli, 2016). Les abeilles permettent de déterminer la dégradation chimique de l'environnement dans lequel elles vivent par deux méthodes dont l'une consiste à évaluer les résidus chimiques qu'on peut retrouver sur leur corps ou dans les produits de la ruche (Sabatini, 2005).

Cependant, depuis quelques années, le phénomène de disparition des populations d'abeilles semble être un phénomène mondial. En effet, entre 2006 et 2007, des pertes de 60%, 40%, 25% et 30% ont été respectivement enregistrées aux USA, au Québec, en Allemagne et en France (Global research, 2008). En outre, des pertes de colonies d'abeilles allant de 40,61% à 58,34% ont été notées au Sud-ouest du Nigeria (Akinwande, 2013), en Afrique du Sud des pertes de 29,6% et 46,2% ont été également rapportées en 2010 et 2011 (Pirk, 2014) et en Turquie les pertes de colonies en raison de l'hiver ont été évaluées à 14,5%, 18,6% et 12,6% en 2009, 2010 et 2011 respectivement (Ivgintunca *et al*., 2016).

D'après AFSSA (2008) et PAN Europe (2010) quarante causes liées au déclin des abeilles ont été recensées parmi lesquelles: les parasites et maladies de l'abeille; les intoxications phytosanitaires; la raréfaction des ressources alimentaires pour les abeilles et l'intensification des pratiques apicoles et agricoles. Cependant, il existe un déficit de données pertinentes pour analyser ce problème dont les causes sont multifactorielles (Gerster, 2012).

Au Sénégal, l'agriculture occupe 73,8% des ménages en milieu rural et l'apiculture est une activité secondaire menée par 85% des agriculteurs (RGPHAE, 2014). Cependant, malgré les multiples actions de modernisation entreprises par le gouvernement depuis les années 1961, la filière apicole Sénégalaise n'est pas bien métrisée et les actions de développement entreprises sont dirigées vers la production de miel uniquement (Diouf,

2002). Par ailleurs, en 2012 l'activité apicole Sénégalaise a été marquée par la disparition spectaculaire des abeilles dans certaines régions du pays comme Fatick, Kolda et Ziguinchor (Tine, 2014).

Au Sénégal, rare sont les études entrepris dans le domaine apicole. C'est ainsi que cette étude se fixe pour objectifs, d'évaluer la production de miel dans trois (Vélingara, Fatick et Thiès) grands bassins apicoles du pays à fasciés agroécologiques différentes étalé sur quatre années et d'identifier les facteurs inhibiteurs de cette production. Ce qui nous a conduit à poser les hypothèses suivantes:

La production de miel au Sénégal, varie telle entre les zones agroécologiques suivant les années?

Le phénomène de disparition des colonies d'abeilles est-il observé au Sénégal?

Les prédateurs des abeilles menacent ils la production du miel?

## Matériels et Méthode

*Présentation des zones et de la période d'étude*

Les enquêtes se sont déroulées entre Septembre 2014 et Janvier 2016 à Vélingara, Toubacouta, la zone des Niayes et Bandia / village. Ces quatre sites sont répartis dans trois régions du Sénégal (Fatick, Thiès et Kolda). Vélingara est un des départements de la région de Kolda situé au sud du pays. Il est caractérisé par un climat de type soudano guinéen (Leroux,1983) avec des précipitations moyennes annuelles qui varient entre 700 et 1300 mm sur cinq mois qui s'étalent de Juin à Octobre et une saison sèche qui dure sept mois. Dans cette région, les températures moyennes mensuelles varient de 25°C en Décembre à 40°C en Mars (ANSD/SRSD Kolda, 2010). Les sites de Toubacouta (Fatick), de Bandia village et de la zone des Niayes (Thiès) situé à l'Ouest du pays sont caractérisés par un climat à dominante sub canarien (Leroux,1983) et une alternance de deux saisons très contrastées: Une saison sèche d'une durée de neuf mois et une saison pluvieuse de trois mois qui s'étend de juillet à Septembre. A Toubacouta, la température moyenne oscille entre 25°C en saison des pluies et 45°C en saison sèche avec une moyenne annuelle pluviométrique de 871,45 mm (PDC Toubacouta, 2016). Dans la zone des Niayes placée sous l'influence quasi permanente des alizés maritimes qui lui confère un climat particulier par rapport à l'intérieur du pays et à Bandia/village, les précipitations sont en moyenne de 350mm par an avec des températures moyennes dépassant rarement 30°C (Camara, 2010 ; Diop, 2013) (Figure 1)

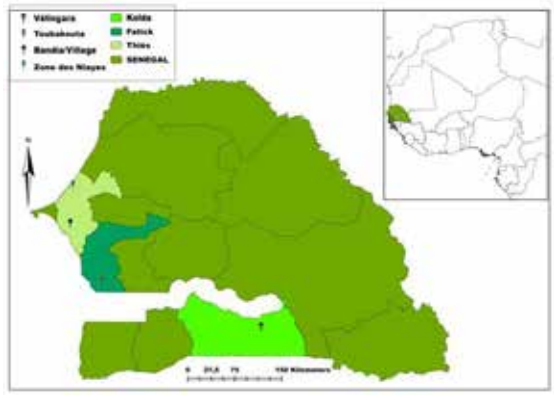



**Figure 1 :** Carte de localisation des zones d'étude

*Méthodologie*

Afin atteindre l'objectif fixé par cette étude, nous avons effectué des enquêtes descriptives au cours desquelles un guide d'entretien et un questionnaire élaboré selon les exigences de: The COLOSS BEEBOOK : Survey Methods (van der Zee *et al*., 2013) ont été administrés aux groupements apicoles et aux apiculteurs individuels à travers des focus groupes et des entretiens individuels. Le choix des apiculteurs individuels et des groupements interviewés (Tableau 1) s'est fait grâce aux informations reçues aux près des consultants en apiculture et des organisations encadrant les apiculteurs (liste de localités ou est pratiquée l'apiculture et parfois même des identités d'apiculteurs, Noms d'associations d'apiculteurs…).

Les entretiens et questionnaires ont porté essentiellement sur:

- les connaissances, aptitudes et pratiques de l'apiculture;
- le nombre de ruches détenues par

association d'apiculteurs et par apiculteur individuel;
- la production et l'écoulement du miel et de ses sous produits;
- les difficultés rencontrées dans la production du miel;
- l'utilisation des produits chimiques dans l'activité apicole.

Le questionnaire nous livre aussi des informations concernant l'organisation des apiculteurs et le matériel apicole.

Pour le traitement des données, le logiciel Epi-Info 3.5.4 (CDC, 2012) a permis d'obtenir les statistiques descriptives puis les tableaux et graphiques ont été élaborés avec Excel. Les tests de Barlett et de Bonferroni ont été utilisés pour effectuer la comparaison entre les moyennes de production de miel respectivement deux à deux entre les différentes zones et à travers les années à l'aide du logiciel STATA version 9.0 (Statacorp, 2005).

## Résultats

*Répartition de la population d'étude*

Au total 32 groupements d'apiculteurs et 138 apiculteurs individuels ont été interrogés dans les quatre zones d'étude. La répartition des populations enquêtées suivant les sites est consignée dans le tableau 1

*Suivi de la production annuelle de miel sur 4 années*

Chez les associations d'apiculteurs, la production moyenne de miel par association d'apiculteur en fonction du nombre de ruches de 2011 à 2014 était de 695,25 Kg, 1003,66 kg, 2446,5 kg, et de 2979,25 kg à Toubacouta, Bandia/village, à Vélingara et dans la zone des Niayes respectivement ; alors que la production moyenne annuelle de miel par apiculteur individuel en fonction du nombre de ruches était évaluée à 44,86 kg, 126,25 kg, 35,33kg et 91,44 kg dans les mêmes zones dans le même ordre (Figure 2). La production annuelle par apiculteur variait entre 3 et 560 kg.

Les résultats de la comparaison des moyennes de productions annuelle de miel entre les sites et selon les années sont consignés dans le tableau 2.

Sur les 138 apiculteurs individuels et 32 associations d'apiculteurs interrogés, 120 (86,9%) et 21(65,6%) respectivement ont souligné que leur production de miel était en baisse contre seulement 14 (10, 1%) et 5 (15,6%) qui pensaient que la production était en augmentation.

Selon les apiculteurs, cette baisse de la production de miel serait liée aux facteurs ci-dessous.

*Facteurs associés à la baisse de la production de miel par les apiculteurs*

*Perturbations notifiées par les apiculteurs*

79% (108 apiculteurs individuels) et 97% (31 groupements d'apiculteurs) mentionnèrent des perturbations dans le cadre de leur activité. En effet, sur l'ensemble des sites, l'abandon des ruches représentait 52% des perturbations notées, suivi de la mortalité des abeilles avec 35% (Cf. Figure 3). Toutefois, l'importance du phénomène variait en fonction des sites. Elle représentait 62,90% à Foundiougne, 36,40% à Bandia/village, 50% dans la zone des Niayes et 49% à Vélingara (Cf. Figure 4).

*Autres facteurs incriminés par les apiculteurs dans la baisse de la production du miel*

Les apiculteurs avaient associé trois types de facteurs à la baisse de la production de miel à savoir des facteurs anthropiques (feux de brousse, usage des pesticides chimiques dans l'agriculture, …), des facteurs non anthropiques (baisse de la pluviométrie) et Facteurs pouvant être classé à la fois dans les deux premiers (Cf. Tableau 3).

## Discussion

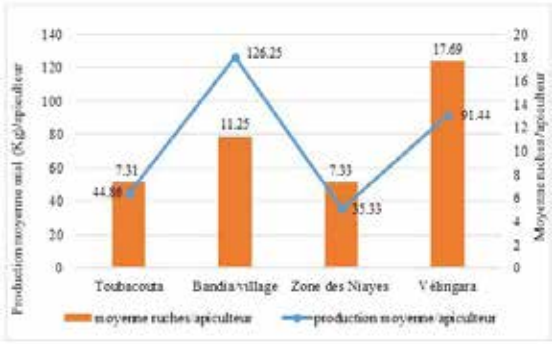
Il ressort de cette étude (Tableau 2) que la différence de production moyenne de miel par association d'apiculteur pour 2011 et 2012, était hautement significative entre les sites avec respectivement $p= 0,0007$ et $p= 0,0016$ et significative en 2014 ($p<0,05$). Contrairement en 2013 où la différence de production n'était pas statistiquement significative entre les sites ($p= 0,307$). De plus, le même tableau montre

**Tableau 1 :** Répartition des associations et apiculteurs individuels enquêtés par site.

| Localités /Régions | Associations d'apiculteurs | Apiculteurs individuels |
|---|---|---|
| Toubacouta /Fatick | 14 | 31 |
| Bandia Village/Thiès | 4 | 4 |
| Zone des Niayes/ Thiès | 2 | 3 |
| Vélingara /Kolda | 12 | 100 |
| **Total** | **32** | **138** |




a : Nombre moyenne de ruches et production moyenne annuelle (Kg) de miel par association selon le site de 2011 à



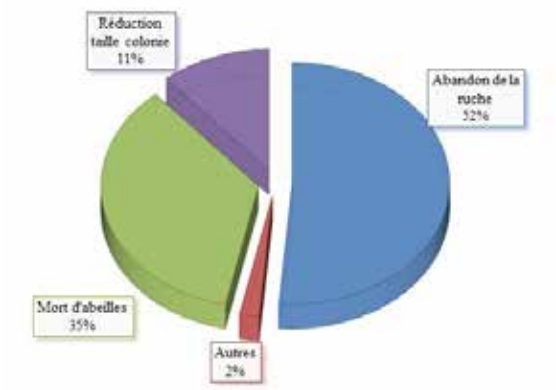

b: Nombre moyen de ruches et production moyenne annuelle de miel /apiculteur individuel selon le site entre 2011 et 2014

**Figure 2 :** Nombre moyen de ruches et production moyenne annuelle de miel chez les apiculteurs (associations et individuels) selon le site entre 2011 et 2014

**Tableau 2 :** Comparaison des production moyenne de miel (Kg) par association d'apiculteur

| Années | Paramètres | 2011 | 2012 | 2013 | 2014 | Valeur de P |
|---|---|---|---|---|---|---|
| **Zones d'étude** | | | | | | |
| 1. Toubacouta | N1 | 7 | 7 | 9 | 8 | 0,3652 |
| | Production moyenne | 27,28 (34,87)[a] | 52,42 (74,06)[a] | 68,22 (98,19)[a] | 201,12 (430,46)[a] | |
| 2. Bandia/village | N2 | | 3 | 4 | 4 | 0,1632 |
| | Production moyenne | ND | 355,67 (151,48)[a] | 267,50 (182,14)[a] | 218,50 (189,28)[a] | |
| 3. Zone des Niayes | N3 | 2 | 2 | 1 | 2 | 0,014 |
| | Production moyenne | 1907,50 (2273,35)[b] | 1132,50 (1443,20)[b] | 3130 (0)[a] | 1353,50 (1744,43)[b] | |
| 4. Vélingara | N4 | 3 | 7 | 9 | 6 | 0,2458 |
| | Production moyenne | 648,33 (947,15)[a] | 227,14 (348,39)[a] | 371,78 (540,21)[a] | 484,17 (663,75)[a] | |
| Valeur de P | | P= 0,0007 | P= 0,0016 | P= 0,307 | P=0, 034 | |

*() = Ecart type*
*ND Non disponible*




*Autres= Vol de ruches ; raréfaction des abeilles

**Figure3 :** Répartition globale des perturbations notées

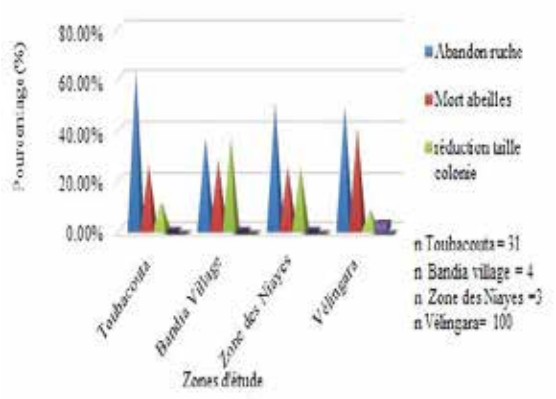



**Figure4 :** Types de perturbations notées par département (en valeur relative)

**Tableau 3 :** Classification des causes des perturbations notées dans l'activité apicole notifiées par les apiculteurs

| Facteurs liés à l'homme (apiculteurs et non apiculteur) | Facteurs liés aux prédateurs et aux maladies d'abeilles | Facteurs liés à l'environnement et à la nature des abeilles |
|---|---|---|
| • Abattage des arbres (déforestation)<br>• Insuffisance de la formation des apiculteurs<br>• Ruches exposées au vent<br>• Ruches étroites<br>• Absence de reine dans la ruche<br>• Ruches en ciment chauds, trop vastes et inadaptés<br>• Mauvais entretien des ruches<br>• Ruches très anciennes<br>• Mauvais emplacement des ruches<br>• Feux de brousse<br>• Cire très ancienne<br>• Présence de beaucoup de vent<br>• Utilisation du feu dans la récolte du miel | • Attaque par Athenia tumidae<br>• Attaque par la Varoie<br>• Attaque par la fausse teigne<br>• Attaque par les araignées<br>• Coléoptères<br>• Coccinelles «cooé»<br>• Fourmies (rouges et noires)<br>• Insectes<br>• Souries<br>• Termites<br>• Infiltration des margouillats et lézards dans les ruches<br>• Maladies des abeilles<br>• Serpents<br>• Ecureuils<br>• Attaque par les animaux sauvages<br>• Oiseaux<br>• Rats palmistes | • Accidentelle<br>• Colonies très petites<br>• Courte durée de vie des abeilles<br>• Manque de colonies d'abeilles<br>• Mort massive des abeilles<br>• Essaimage naturel due à une race capricieuse<br>• Pillage entre les abeilles<br>• Effets des intempéries<br>• Manque de nourriture<br>• Milieu brouillant<br>• Forte chaleur (climat trop chaud)<br>• Baisse de la pluviométrie<br>• Manque de d'eau<br>• Usage des pesticides dans l'agriculture<br>• Colonies âgées |

que dans les zones de Toubacouta, Bandia/ village et Vélingara, la différence de production de miel n'était pas statiquement significative en fonction des années. En revanche, dans la zone des Niayes, la production de miel par groupement d'apiculture était plus importante en 2013 et la différence de production selon les années était statistiquement significative dans cette zone (p= 0,014).

L'analyse du tableau 2 montre aussi que la production de miel par groupement à l'intérieure des sites de Toubacouta, Zone des Niayes et Vélingara était très hétérogène. Cependant, elle était homogène dans le site de Bandia avec des écart-types très inférieures à la moyenne de production. Cela pourrait s'expliquer par le fait que dans cette zone, les associations ont placées leurs ruches dans la forêt classée unique que compte le village contrairement aux autres sites où les associations sont localisées dans des zones écologiquement différentes.

En ce qui concerne les apiculteurs individuels, la différence de production annuelle de miel était hautement significative selon la zone d'étude (P<<0,001).

Les différences significatives et parfois très élevées notées dans la production du miel entre les sites pourraient s'expliquer par le fait que les sites sont très différents du point de vue agroécologique mais aussi par les disparités existantes dans la modernisation du secteur malgré les efforts consentis par les ONGs et l'Etat su Sénégal.

L'analyse de la figure 2 montre que la production de miel ne dépendait pas du nombre de ruches. Par ailleurs, il faut noter que chez les apiculteurs individuels, la production réelle de miel est très mal connue cela pourrait être lié au caractère secondaire qu'occupe l'activité mais également du faible niveau de scolarisation des apiculteurs. Cette remarque est également valable pour la production de la cire dont les apiculteurs n'ont pas pu donner le volume.

Les différents facteurs mis en exergues par cette étude montrent que l'apiculture est confrontée à des problèmes multiples et variés dont l'ampleur variait selon la zone. Le tableau 3 révèle une origine multifactorielle des perturbations. Parmi les facteurs cités, on pouvait noter les prédateurs des abeilles, les mauvaises pratiques apicoles et l'environnement. La fausse teigne et la varoise ont été également notifiées. D'autre part, la caractérisation de ces facteurs montre que, les ennemis des abeilles occupent de loin la première place 79% à Foundiougne, 65% à Bandia/village, 33% dans la zone des Niayes et 68% à Vélingara (Figure 5). En effet, parmi les prédateurs désignés figurent les araignées, les coccinelles du genre Athenia tumidae, les coléoptères, les écureuils, les fourmis les serpents et d'autres insectes non identifiés.

Les résultats de l'étude effectuée par Akinwande (2013) indiquaient que 100% des colonies examinées dans son étude étaient infectées de criquets, de fourmis, de coléoptères, termites et d'araignées. En plus, Tesfaye (2017) aussi soulignait dans son étude que la présence des ravageurs et des prédateurs des abeilles constituait un défit majeur pour l'apiculture et les apiculteurs de la zone de Bale au sud-est de l'Ethiopie.

Notre étude confirme les résultats précédents car les ennemis cités par ces auteurs étaient à plus de 50% responsable de l'abandon des ruches selon les apiculteurs. Selon Toulec (2008), en France, de 1995 à 2001, la baisse de la production nationale annuelle de miel avait atteint 22%. Les causes d'effondrement des colonies d'abeilles citées par (Toulec, 2008) étaient similaires à celles indexées dans notre étude par les apiculteurs. En effet, il soulignait des facteurs liés à l'environnement (conditions météorologiques, sources nectarifère et pollinifères, pesticides, champs électriques et magnétiques), aux parasites mais également aux apiculteurs. Ces mêmes facteurs ont été cité par la population de cette d'étude (Cf. Figure 5). Toutefois, en incriminant les apiculteurs, Toulec (2008) évoquait le mauvais choix des médicaments dans le traitement des maladies ce qui peut favoriser des maladies et parasitismes mais également conduire à la résistance des abeilles face aux parasites, à l'alimentation hivernale insuffisante des abeilles qui peut entrainer un affaiblissement voire la

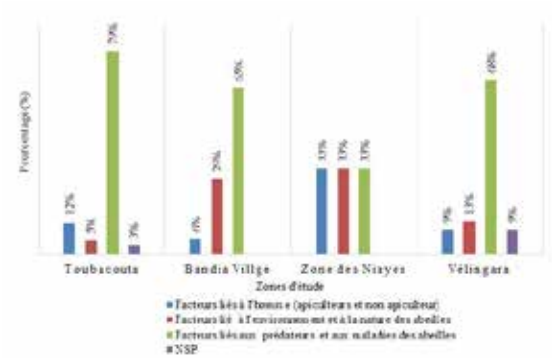



**Figure 5 :** Caractérisation des causes des perturbations notées dans la pratique apicole

disparition d'une colonie ce qui n'est pas le cas de notre étude.

Cependant, au Sénégal les facteurs environnementaux notifiés par les apiculteurs étaient la baisse de la pluviométrie, la sécheresse, température/humidité relatives élevée et la disparition de certaines espèces d'abeilles. Dans notre étude, les causes liées à l'environnement représentaient 20% des causes de perturbations notifiées par les apiculteurs. Ceci est corroboré par Adjlane *et al*. (2012) qui indique que 28% de la mortalité d'abeilles signalées en Algérie sont attribués à la dégradation de l'environnement qui conduit à un manque de nourriture pour les abeilles et indexe également les pratiques apicoles. Aussi, les mauvaises pratiques apicoles telles que l'utilisation du feu à la récolte, les feux de brousse, le mauvais emplacement des ruches, le mauvais entretien des ruches et la non maîtrise du calendrier apicole sont les facteurs qui ont été imputés à l'apiculteur. L'utilisation des produits chimiques dans l'agriculture a été également indexée par les populations enquêtées. Tout cela pourrait être lié au manque de formation et à l'insuffisance de matériel de récolte. L'étude d'Akinwande (2013) au Nigéria confirme nos résultats.

Des études antérieures effectuées par Ndiaye (1974) et Diouf (2002) avaient montré qu'à l'image de la plupart des pays tropicaux, au Sénégal, les prédateurs des abeilles sont les plus redoutés à cause de leur nombre et de l'importance de leurs dégâts. Les résultats de l'étude menée par M'peindagha Bongho (2009) au Burkina Faso confirme l'existence du nombre important d'insectes dans les ruches et leurs effets négatifs sur le développement normale des colonies d'abeilles, le rendement et la qualité de la production. Nos résultats étaient également en conformités avec ceux de Dietemann *et al*. (2009) qui en outre rapportent que la plupart des maladies d'abeilles sont présentes en Afrique sans effets délétères à grande échelle. Ils justifient cette situation par la résistance ou à l'adaptation des abeilles Africains à beaucoup de parasites. V. destructor à été notifié dans le cadre de notre étude mais sans beaucoup d'importance. L'étude menée par Muli *et al*. (2014) au Kenya sur l'impact des parasites et pathogènes sur les abeilles montrait que bien que présents, ces derniers ne semblaient pas encore avoir d'impact sur les abeilles ainsi, cette étude vient corroborer nos résultats.

En outre, les perturbations notées à la figure 3 étaient similaires à celles rapportées par Paterson (2006).

Par contre, selon Adjlane *et al*. (2012), en Algérie, l'agent principalement suspecté concernant les mortalités observées était le Varroa destructor, agent causal de la varroase.

Nos résultats étaient également différents de ceux soulignés par Tirado *et al*. (2013) et Pirk (2014) en Afrique du Sud. Conformément à ce dernier, parmi les principales causes de mortalités perçues par les apiculteurs en Afrique du Sud figuraient les varroas, les essaims (essaimage non reproductif) et les Chalcodes. D'après Tirado *et al*. (2013), les maladies des abeilles étaient parmi les causes les plus inquiétantes dans les pays développés. Cette différence des causes incriminées, pourrait s'expliquer par la différence du niveau de modernisation de l'apiculture entre les continents mais également par la différence des cadres de vie des abeilles et par la nature des espèces d'abeilles elles mêmes. En effet, le nombre d'études effectuées sur les maladies des abeilles témoigne de l'importance qu'occupent celles-ci dans les pays développés. Le principal suspect concernant le CCD « Colony Collapse Disorder» est, sans doute, Varroa mite destructor, non seulement

**Tableau 6 :** Facteurs indexés dans la baisse et/ou l'irrégularité de la quantité de miel produit suivant la zone.

| **Départements** | **Facteurs non anthropiques** | **Facteurs anthropiques** | **Facteurs pouvant être à la fois anthropiques et non anthropiques** |
|---|---|---|---|
| Toubacouta | • Baisse de la pluviométrie<br>• Sécheresse | • Déforestation<br>• Feux de brousse<br>• Mauvaises pratiques de récolte du miel<br>• Usage des produits chimiques dans l'agriculture | • Disparition de certaines espèces d'abeilles<br>• Maladies des abeilles<br>• Baisse de la floraison des plantes |
| Bandia/ Village | • Manque de point d'eau | • Déforestation<br>• Pollution due aux carrières<br>• Vieillissement de la forêt d'eucalyptus<br>• Usage de l'ammoniac dans les carrières | • Désertion des colonies d'abeilles |
| Zone des Niayes | • Baisse de la pluviométrie | • Usage des pesticides chimiques dans le maraîchage | • Maladies des abeilles<br>• Désertion des colonies d'abeilles |
| | • Baisse de la pluviométrie | • Déforestation<br>• Feux de brousses<br>• Fumée provenant des fours de charbon<br>• Mauvaises pratiques de récolte du miel<br>• Usage des pesticides chimiques pour la protection des cultures<br>• Non maîtrise des périodes d'installations des ruches<br>• Vol de ruches<br>• Insuffisance de ruches modernes | • Disparition de certaines espèces d'abeilles<br>• Disparition ou raréfaction de certaines plantes mellifères |

au Québec Boucher et Desjardins (2010) et dans le reste du Canada (Currie *et al*., 2010) mais également dans plusieurs pays du monde comme les États-Unis, l'Autriche, le Luxembourg et le Lichtenstein (Haubruge *et al*., 2006). Ces résultats confirment une fois encore la dimension planétaire du syndrome d'effondrement des colonies d'abeilles: et ces causes multiples qui peuvent varier d'un continent à l'autre.

## Conclusion

Il ressortait de cette étude qu'il existait, une différence très significative de la production du miel dans les différentes zones apicoles du Sénégal et que le phénomène de disparition des colonies est aussi une réalité dans ce pays. Plusieurs causes ont été incriminées tels que les facteurs environnementaux, la variété multiple de prédateurs qui perturbent quotidiennement la survie des abeilles en plus des mauvaises actions humaines qui restent inquiétantes. Vue l'importance du rôle des abeilles sur le plan sécurité alimentaire, économique et création d'emplois, des études approfondies sur le phénomène de disparition des colonies d'abeilles au Sénégal sont certes nécessaires mais ont pourrait commencer par contrôler l'usage des pesticides, maîtriser les prédateurs des abeilles et renforcer les capacités de production des apiculteurs et l'utilisation des techniques semis modernes afin de réduire les menaces comme la désertion des ruches et booster la production apicole du pays.

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# PREVALENCE ET INCIDENCE SOCIO-ECONOMIQUE DES PRINCIPAUX MOTIFS DES SAISIES DE VIANDE *Bovine* A L'ABATTOIR MUNICIPAL DE KOUSSERI AU CAMEROUN

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## Resume

Des enquêtes ont été menées rétrospectivement sur une période de dix ans allant de 2004 à 2014 et de manière prospective de janvier à juin 2017 dans le but de déterminer la nature et la fréquence des principaux motifs des saisies de viande et abats chez les bovins abattus à l'abattoir municipal de Kousseri au Cameroun ainsi que l'incidence socio-économique associée. L'unité épidémiologique était les lots d'animaux abattus de race, d'âge et de sexe différents, provenant d'élevages différents. Sur un total de 38840 bovins abattus, 17483 animaux présentaient des lésions ayant conduit aux saisies de viande soit une prévalence de 45,01%. Ainsi, les saisies sont le tribut que payent l'élevage et les bouchers pour protéger la santé de l'homme.

**Mots-clés :** Viandes, saisies, prévalence, incidence, abats et abattoir.

# PREVALENCE AND SOCIO-ECONOMIC IMPACT OF THE MAIN REASONS FOR SEIZURES OF BEEF AT THE KOUSSERI MUNICIPAL SLAUGHTERHOUSE IN CAMEROON.

## Abstract

Two surveys we conducted retrospectively over a ten year period from 2004 to 2014 and prospectively from January to June 2017 at the municipal kousseri slaughterhouse in Cameroon. The service aimed to determine the nature and frequency of the main reasons for seizures of meat and offal in slaughtered cattle and the associated socio-economic impact. The epidemiological unit was the batches of slaughtered animals of different breeds, age and sex from different farms. Out of a total of 38,840 slaughtered cattle, 17,843 animals had lesions leading to meat seizures, with a prevalence of 45.01%. Thus, seizures are the penalty paid by livestock farmers and butchers to protect human health.

**Key-words:** Meat, seizures, prevalence, incidence, meat offal and slaughterhouse.

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## Introduction

Le Cameroun, comme la majorité des Etats africains, a une économie essentiellement agropastorale et les revenus tirés de l'élevage (surtout bovin) ne sont pas négligeables [1]. Les bovins sont les principales sources de viande et d'abats pour le Cameroun et sont exportés vers les pays voisins (Gabon, Guinée Equatoriale, Nigéria). Cet élevage fournit également de la matière première à l'industrie du cuir [2]. Cependant, un nombre significatif d'organes et de carcasses sont saisis à l'abattoir à cause de la présence de lésions d'origines diverses. Dans le but de protéger la santé publique et de moraliser les transactions commerciales, les animaux de boucherie, leurs viandes, abats et issues destinés à l'alimentation humaine sont soumis à une inspection sanitaire et de salubrité. Elle a pour buts essentiels de protéger la santé publique et animale, d'assurer la loyauté des transactions commerciales, mais aussi de limiter des pertes liées aux mauvaises conditions de préparation, de stockage et de commercialisation de ces denrées. En marge de ce qui précède, un contrôle minutieux de ses caractéristiques bactériologiques, parasitologiques et organoleptiques s'impose avant la commercialisation de la viande ; ce qui aggrave souvent la faible production animale observée pour des raisons de non-conformité, de soustraction de certains organes ou carcasses d'animaux de la consommation humaine après expertise des viandes.

Les pertes enregistrées n'incombent pas seulement à la quantité des protéines consommables, mais aussi aux liquidités en termes d'argent pour le vendeur. Plusieurs motifs parmi lesquels l'absence d'examen ante-mortem, les maladies parasitaires et infectieuses, le manque de rigueur dans le contrôle sanitaire, les techniques d'abattage seraient à la base des saisies de viande. Cette étude s'est assignée comme objectifs de connaitre la fréquence des principaux motifs des saisies et de déterminer les principales raisons pour lesquelles, les viandes sont saisies à l'abattoir municipal de Kousseri ainsi que les pertes socio-économiques associées.

## Materiel et Methodes

*Zone d'étude*

L'étude a été menée à l'abattoir municipal de la ville de Kousseri à l'Extrême-nord du Cameroun. La ville de Kousseri, Chef lieu du Département du Logone et Chari, est située entre le 12ème degré de latitude Nord et le 15ème degré de longitude Est. Elle couvre une superficie de 160 km2 et la population est estimée à 120.000 habitants [3]. Le climat est de type sahélien semi-aride avec une longue saison sèche d'octobre à mai et une courte saison de pluie de juin à septembre. La pluviométrie annuelle est comprise entre 500 et 600 mm et les températures moyennes oscillent entre 35°C et 45°C. L'économie est basée sur l'élevage, l'agriculture, la pêche et le commerce. La situation géographique de la ville de Kousseri comme porte d'entrée du Cameroun en provenance du Tchad et du Nigéria fait d'elle une ville frontalière et commerciale, et représente un véritable carrefour d'échanges entre les trois pays.

*Choix et caractéristiques de l'abattoir municipal de Kousseri*

L'abattoir municipal de Kousseri a été choisi en fonction de son accessibilité, de la concentration des abattages, de la disponibilité des éleveurs et commerçants à abriter nos travaux, de la collaboration de la Délégation Départemental de l'Elevage, des Pêches et des Industries Animales du Logone et Chari.

Construit en 1983, l'abattoir municipal de Kousseri ploie sous le poids de l'âge, mais continue néanmoins à remplir sa mission. Il est situé au quartier Arazaï, à l'entrée sud de la ville de Kousseri. C'est un abattoir de type traditionnel, construit pour servir d'aire d'abattage et d'inspection des animaux de boucherie. L'abattoir comprend une salle semi-ouverte destinée au sacrifice et à l'éviscération. Le sol est bétonné et quatre potences servent à la suspension des carcasses à l'aide de crochets en fer. Un bac relié à un forage électrique sert de point d'approvisionnement en eau. La chaine de froid est inexistante. L'abattoir fonctionne chaque jour de lundi à dimanche de 05 heures

à 17 heures. Le nombre de bovins abattus par jour varie de 30 à 150. Les inspections sanitaires qui sont menées par les agents des services vétérinaires, sont sanctionnées par des cachets apposés sur les viandes éligibles à la consommation.

*Matériel*

Les animaux abattus au sein de l'abattoir municipal de Kousseri proviennent essentiellement d'élevages différents du Département du Logone et Chari, du Tchad, du Nigéria et du Niger.

Les données statistiques relatives aux abattages et aux saisies opérées ont été obtenues grâce aux registres et rapports annuels d'activités de l'abattoir municipal de Kousseri et de la Délégation Départementale de l'Elevage, des Pêches et des Industries animales du Logone et Chari [4].

*Méthodes*

Une première enquête rétrospective a permis de recueillir les résultats des examens macroscopiques post-mortem effectués par les services vétérinaires sur 38840 bovins abattus de 2004 à 2014 à l'abattoir municipal de Kousseri soit une période de dix ans.

Une deuxième enquête prospective a été effectuée à l'abattoir municipal de Kousseri de janvier à juin 2017 par l'examen macroscopique de 823 bovins abattus en présence des inspecteurs vétérinaires.

Le poids des animaux abattus n'étant pas mentionné dans les documents exploités, la quantité totale de viande traitée à l'abattoir a été estimée en faisant le produit du nombre total d'animaux abattus et du poids moyen d'une carcasse ; ce poids moyen étant obtenu par des pesées successives réalisées sur différents animaux.

Pour l'évaluation des pertes économiques dues aux saisies, les quantités observées ont été rapportées au prix moyen de vente du kilogramme de viande et au prix de l'organe saisi.

*Analyses statistiques*

L'échantillonnage portait sur les données de registres et rapports d'activités de l'abattoir de 2004 à 2017 et celles de la période de janvier à juin 2017.

Les données ont été analysées après transformation par le test ANOVA. L'appréciation des bovins et des principaux motifs des saisies de viande a été fait par le test de Fischer Snedecor [5] [6].

## Resultats

*Evolution des abattages contrôlés à l'abattoir municipal de Kousseri*

Durant la période allant de janvier 2004 à décembre 2014, 38840 bovins ont été abattus à l'abattoir municipal de Kousseri. Le tableau 1 présente l'évolution des abattages opérés durant cette période.

De même, pendant la période allant de janvier à juin 2017, 823 bovins ont été abattus et examinés à l'abattoir municipal de Kousseri. Le tableau 2 donne l'évolution mensuelle des abattages contrôlés.

*Prévalence des principaux motifs des saisies de viande*

Les résultats de nos recherches sont présentés par les tableaux 3 à 8 qui suivent.

Chez les 38840 bovins abattus en dix ans, 17483 cas de saisie ont été enregistrés à l'abattoir municipal de Kousseri soit une

**Tableau 1 :** Répartition annuelle des abattages contrôlés des bovins à l'abattoir municipal de Kousseri de 2004-2014.

| **Année** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Nombre d'animaux abattus | 2925 | 2987 | 3796 | 3393 | 4212 | 3931 | 4244 | 3128 | 5289 | 1266 | 3669 |
| **Total** | | | | | | **38840** | | | | | |

**Tableau 2 :** Répartition mensuelle des abattages contrôlés à l'abattoir municipal de Kousseri de janvier à juin 2017.

| **Mois** | **Janvier** | **Février** | **Mars** | **Avril** | **Mai** | **Juin** |
|---|---|---|---|---|---|---|
| Nombre d'animaux abattus | 112 | 131 | 138 | 144 | 146 | 152 |
| **Total** | | | **823** | | | |

**Tableau 3:** Prévalence annuelle des saisies de viande à l'abattoir municipal de Kousseri de 2004 à 2014

| **Année** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Nombre de saisies | 586 | 1490 | 2739 | 2048 | 2465 | 2078 | 1616 | 1123 | 1784 | 351 | 1203 |
| Prévalence (%) | 20 | 49,9 | 72,1 | 60,4 | 58,5 | 52,9 | 38,1 | 35,9 | 33,7 | 27,7 | 33,5 |

**Tableau 4 :** Prévalence des principaux motifs des saisies de 2004 à 2014

| **Motifs des saisies** | **Nombre de cas de saisie** | **Prévalence (%)** |
|---|---|---|
| Distomatose | 2074 | 28,6 |
| Pleurésie | 1797 | 24,8 |
| Tuberculose | 1166 | 16,1 |
| Emphysème | 693 | 09,6 |
| Abcès | 577 | 08 |
| Congestion | 316 | 04,4 |
| Mammite | 256 | 03,5 |
| Pneumonie | 216 | 03 |
| Péricardite | 144 | 02 |
| Cysticercose | 5 | 00,07% |
| **Total** | **7244** | **100** |

prévalence de 45,01%. Le tableau 4 présente la prévalence des principaux motifs des saisies de viande observée à l'abattoir.

La distomatose a été l'altération qui a entrainé plus de saisies (28,6%), suivie de la pleurésie (24,8%) et de la tuberculose (16,1%). La péricardite et la cysticercose occupent le bas du tableau avec respectivement des taux de saisie de 2% et 0,07%.

Par ordre d'importance décroissante, les altérations répertoriées se présentaient de la manière suivante : distomatose, pleurésie, tuberculose, emphysème, abcès, congestion, mammite, pneumonie, péricardite et cysticercose. Le tableau 5 présente la prévalence des principaux motifs des saisies observées à l'abattoir municipal de Kousseri de janvier à juin 2017.

La distomatose a été l'altération qui a entrainé plus de saisies (34,7%), suivie de la tuberculose (13,5%), de la congestion (12,8%) et de l'écoffrage (10,6%). La péripneumonie contagieuse *bovine* (3,4%) et les autres motifs des saisies viennent en dernières places. Par ordre d'importance décroissante, les principaux motifs des saisies inventoriées se présentent de la manière suivante : distomatose, tuberculose, congestion, écoffrage, abcès, pneumonie et emphysème, autres motifs et péripneumonie contagieuse *bovine*. Le tableau 6 quantifie les viandes saisies en cours de la période allant de janvier à juin 2017.

**Tableau 5 :** Prévalence des principaux motifs des saisies de janvier à juin 2017

| Motifs des saisies | Nombre de cas de saisies | Prévalence (%) |
|---|---|---|
| Distomatose | 154 | 34,7 |
| Tuberculose | 60 | 13,5 |
| Congestion | 57 | 12,8 |
| Pneumonie | 25 | 05,6 |
| Ecoffrage | 47 | 10,6 |
| Emphysème | 25 | 05,6 |
| PPCB | 15 | 03,4 |
| Abcès | 40 | 09 |
| Autres motifs | 21 | 04,7 |
| **Total** | **444** | **100** |

*PPCB = Péri Pneumonie Contagieuse Bovine*

**Tableau 6 :** Répartition de la quantité des viandes saisies par motifs de janvier à juin 2017.

| Motifs des saisies | Quantités de viandes saisies en kg | Fréquence (%) |
|---|---|---|
| Distomatose | 101,7 | 29,7 |
| Tuberculose | 69,6 | 20,3 |
| Abcès | 46 | 13,4 |
| Autres motifs | 38,7 | 11,3 |
| Congestion | 29,9 | 08,7 |
| Ecoffrage | 19,7 | 05,8 |
| Emphysème | 16,8 | 04,9 |
| Pneumonie | 11,6 | 03,4 |
| PPCB | 08,2 | 02,4 |
| **Total** | **342,2** | **100** |

*PPCB = Péri Pneumonie Contagieuse Bovine*

Au total 342,2 kg de viande ont été saisis à l'abattoir de Kousseri de janvier à juin 2017. La distomatose à elle seule a représenté 29,7% de saisie sur les six mois. Ce motif de saisie était suivi par la tuberculose (20,3%), des abcès (13,4%) et des autres motifs de saisie (11,3%). La pneumonie et la péripneumonie contagieuse *bovine* ont occupé les dernières places avec respectivement 03,4% et 02,4% des motifs de saisies.

*Les principaux motifs des saisies d'organes*

Les tableaux 7 et 8 donnent respectivement la répartition des principaux motifs des saisies partielle et totale d'organes.

S'agissant des organes, les poumons et le foie ont été les organes les plus concernés par les saisies. La tuberculose a été le motif de saisie qui a engendré les plus importantes saisies partielles. Les principaux motifs de saisies partielles du poumon ont été la congestion (15.4%) et l'écoffrage pulmonaire (13,8%).

La tuberculose est le principal motif de saisie totale. Un seul cas de saisie totale de carcasse pour tuberculose a été enregistré durant la période d'étude. Les saisies totales du poumon ont été effectuées principalement pour cause de tuberculose (12,8%) suivie de l'emphysème (7,9%) et de la PPCB (7,5%). la distomatose a été le principal motif de saisie totale du foie (33,7%). Les prévalences des

**Tableau 7 :** Répartition des quantités d'organes (kg) perdues dues aux saisies partielles.

| Altérations | foie | Poumons | Rate | Reins | Mamelles | Ganglions lymphatiques |
|---|---|---|---|---|---|---|
| Tuberculose | 33 | 46,35 | 4,2 | | 2,5 | 26,28 |
| Distomatose | 136,19 | | | | | |
| Congestion | 05,7 | 75,8 | | | | |
| Abcès | 15,87 | 29,87 | | 0,4 | | |
| Pneumonie | | 28,7 | | | | |
| Ecoffrage | | 67,9 | | | | |
| Emphysème | | 17,6 | | | | |
| PPCB | | | | | | |
| Autres motifs de saisie | 1,83 | | | | | 1,29 |
| **Total** | **192,59** | **266,22** | **4,2** | **0,4** | **2,5** | **27,57** |

*PPCB = Péri Pneumonie Contagieuse Bovine*

**Tableau 8 :** Répartition des quantités d'organes (kg) perdues dues aux saisies totales

| Motifs de saisie | foie | Poumons | Rate | Reins | Mamelles | Cœur | Langue | Ganglions lymphatiques |
|---|---|---|---|---|---|---|---|---|
| Tuberculose | 29,94 | 80,55 | 12,37 | | 3,6 | 3,4 | | 52,56 |
| Distomatose | 212,6 | | | | | | | |
| Congestion | 16,1 | 32,1 | | | | | | |
| Abcès | 15,6 | 1,74 | 11,15 | | | | | |
| Pneumonie | | 17,9 | | | | | | |
| Ecoffrage | | 04,2 | | | | | | |
| Emphysème | | 49,7 | | | | | | |
| PPCB | | 47,3 | | | | | | |
| Cysticercose | | | | | | | 08,4 | |
| Autres motifs | 24,8 | 1,84 | | 1,6 | | | | 2,6 |
| **Total** | **299,04** | **235,33** | **23,52** | **1,6** | **3,6** | **3,4** | **8,4** | **55,16** |

*PPCB = Péri Pneumonie Contagieuse Bovine*

saisies totales des autres organes ont été inférieures à 3% pour chaque organe.

*Incidence socio-économique des saisies de viande*
*Estimation du coût des pertes financières*

A l'abattoir municipal de Kousseri, les prix du kilogramme de viande ont continuellement varié en dix ans et aucune information relative au coût de l'assainissement des carcasses n'était disponible. Du fait de ces difficultés et au regard des rapports des années 2004 à 2014, la moyenne de prix du kilogramme de viande était de 1100 F CFA. Sur la base de ce prix, le tableau 9 nous donne une estimation des pertes financières dues aux saisies de viande de 2004 à 2014.

Les pertes financières directes dues aux saisies de carcasse ont été estimées à 1.071.531,25 F CFA. La tuberculose est le motif de saisie qui a engendré les pertes directes les plus importantes. Le tableau 11 présente les pertes financières dues aux saisies d'organes de janvier à juin 2017.

**Tableau 9 :** Estimation des pertes financières dues aux saisies de viande de 2004 à 2014

| Année | Nombre d'animaux abattus | Proportions des saisies des carcasses et organes (%) | Prix moyen de kg de viande FCFA | Pertes financières |
|---|---|---|---|---|
| 2004 | 2925 | 20,03 | 1100 | 644465 |
| 2005 | 2987 | 49,88 | 1100 | 1.638.907 |
| 2006 | 3796 | 72,15 | 1100 | 3.012.695 |
| 2007 | 3393 | 60,36 | 1100 | 2.252.816 |
| 2008 | 4212 | 58,52 | 1100 | 2.711.349 |
| 2009 | 3931 | 52,86 | 1100 | 2.285.719 |
| 2010 | 4244 | 38,08 | 1100 | 1.777.727 |
| 2011 | 3128 | 35,9 | 1100 | 1.235.247 |
| 2012 | 5289 | 33,73 | 1100 | 1.962.378 |
| 2013 | 1266 | 27,73 | 1100 | 386.168 |
| 2014 | 3669 | 32,79 | 1100 | 1.323.372 |
| **Total** | **38840** | | | **19.230.843** |

**Tableau 10 :** Estimation des pertes financières directes dues aux saisies de carcasse de janvier à juin 2017.

| Motifs de saisie | Tuberculose | Autres motifs de saisie |
|---|---|---|
| Carcasse | 456,25 | 48 |
| Prix moyen du kg de viande | 2125 | 2125 |
| Coût des pertes | 969.531,25 | 102.000 |
| **Total** | **1.071.531 FCFA** | |

**Tableau 11 :** Estimation des pertes financières directes dues aux saisies d'organes

| Motifs de saisie | Foie | Poumons | Rate | Reins | Mamelles | Ganglions lymphatiques |
|---|---|---|---|---|---|---|
| Tuberculose | 62,94 | 126,9 | 16,57 | | 6,1 | 78,84 |
| Distomatose | 348,79 | | | | | |
| Congestion | 21,8 | 107,9 | | | | |
| Abcès | 31,47 | 31,61 | 11,15 | 0,4 | | |
| Pneumonie | | 46,6 | | | | |
| Ecoffrage | | 72,1 | | | | |
| Emphysème | | 67,3 | | | | |
| Péripneumonie | | 47,3 | | | | |
| Autres motifs de saisie | 26,63 | 1,84 | | 1,6 | | 3,89 |
| Prix moyen du kg | 1500 | 1500 | 1500 | 1500 | 1500 | 1500 |
| Coût des pertes | 737.445 | 752.325 | 41580 | 3000 | 9150 | 5.835 |
| **Total** | **1.549.335 FCFA** | | | | | |

Les pertes financières directes dues aux saisies d'organes ont été estimées à 1 549 335 FCFA. La tuberculose et la distomatose sont les motifs de saisie qui ont entrainé les pertes financières les plus importantes représentant respectivement 48,6% et 47,18% de l'ensemble des pertes. Le foie et les poumons sont les organes qui ont engendrés les pertes les importantes. Les autres organes ont entrainé des pertes inférieures à 3%.

Les principaux motifs de saisie de viande entrainent des pertes considérables en protéines animales, ce qui montre à quel point ces saisies sont préoccupantes.

*Incidence sociale des principaux motifs des saisies de viande*

Les problèmes sociaux consécutifs aux saisies de viande et organes touchent principalement le vétérinaire-inspecteur et le boucher. En prononçant la saisie de viande et organes pour les principaux motifs précédemment relevés, le Vétérinaire-inspecteur protège la santé du consommateur contre certaines maladies transmissibles à l'homme par les viandes et organes. Il diminue également la quantité de viandes et organes disponibles pour la consommation. Ainsi, l'inspection de viande dont le but ultime est de protéger la santé publique, fait payer un lourd tribut aux éleveurs et professionnels de la viande.

Les saisies de viande et organes se font au détriment du boucher. Ces derniers ne reçoivent pas de dédommagement en cas de saisie totale de la carcasse et endossent seuls les pertes résultant de l'inspection. Cet état de fait rend les bouchers souvent incompréhensifs et même menaçants (agressifs) d'où certains conflits avec le vétérinaire inspecteur. Ainsi, les saisies sont le tribut que payent l'élevage et les bouchers pour protéger la santé de l'homme.

## Discussion

Les données sur les principaux motifs des saisies de viande *bovine* à l'abattoir municipal de Kousseri de 2004 à 2014 ont montré une prévalence de 45,01%.

Globalement les principaux motifs des saisies observés qui sont la tuberculose, la distomatose, la pneumonie, les mammites, la cysticercose, la péricardite, la congestion, l'emphysème, la pleurésie et les abcès, ne corroborent pas avec ceux rapportés à l'abattoir public de Béni de 2007 à 2011 [7] chez qui la distomatose, la cysticercose, les abcès, les putréfactions, les congestions et les viandes insuffisantes sont les motifs les plus fréquents.

La distomatose, la pleurésie et la tuberculose se sont avérées les principaux motifs des saisies les plus importants avec des prévalences respectives de 28,6%, 24,8% et 16,1%. Ces chiffres sont supérieurs à ceux obtenus à l'abattoir de la SODEPA de 2006 à 2012 [8] et en Ethiopie [9]. La fréquence importante de la distomatose serait due aux conditions climatiques, au mode d'élevage extensif basé sur la mise en pâturage des animaux près des points d'eau (Lac Tchad et fleuve Logone) et à l'absence de programmes de déparasitage systématique des animaux et aux mouvements incessants et non contrôlés des animaux de part et d'autre frontières. Les causes de pleurésie sont multiples et la plupart du temps d'origine bactérienne ou virale. La tuberculose *bovine* est une maladie endémique en Afrique et le Cameroun n'échappe pas à la maladie. La congestion et l'écoffage ont constitué également des motifs de saisie importants avec des prévalences respectives de 12,8% et 10,6%. Ces résultants sont accord avec les travaux réalisés dans les abattoirs en Côte d'Ivoire [10] et au niveau des abattoirs du Cap-Vert [11]. La congestion est une lésion hémorragique observée sur les organes lors des processus inflammatoires et qui peut être consécutive à la présence d'un pathogène au niveau de l'organe atteint. L'écoffrage est généralement dû à la mauvaise saignée lors de l'abattage de l'animal. Cette situation s'explique par le fait que les techniques d'abattage sont précaires à l'abattoir municipal de Kousseri et les animaux sont souvent abattus en état de stress.

Les organes saisis ont été par ordre d'importance les poumons, le foie, les mamelles.

Ces résultats sont en accord avec ceux réalisés à l'abattoir municipal de Ngaoundéré en 2016 [12]. Le foie est l'organe qui a été le plus saisi avec pour principal motif la distomatose. Ce résultat est similaire à celui rapporté à l'abattoir de Gondar en Ethiopie en 2012 [13]. En effet, les douves responsables de la distomatose migrent dans le foie et provoquent une cholangite et une dénaturation du foie conduisant ainsi à une saisie totale ou partielle pour répugnance.

Les autres organes saisis mais à des proportions moindres ont été la rate, les reins et les mamelles. Ces résultats sont en accord avec ceux rapportés à l'abattoir public de la SODEPA en 2016 [14].

Les pertes financières directes causées par les saisies ont été estimées à 21 851 709 FCFA. Ce résultat est inférieur à celui rapporté à l'abattoir de la SODEPA en 2016 [14] et à l'abattoir de Gondar en Ethiopie en 2012 [9]. Les différences entre les pertes financières obtenues dans les différents abattoirs pourraient s'expliquer par le nombre d'animaux abattus, aux différents motifs des saisies et au prix de vente du kilogramme de viande sur le marché.

La tuberculose et la distomatose sont les principales maladies qui ont entrainé des pertes économiques importantes à l'abattoir municipal de Kouseri. Ces résultats montrent qu'à Kousseri, les bovins sont frappés aussi bien par les maladies parasitaires que par les maladies infectieuses.

Ainsi, l'étude des principaux motifs de saisie doit être un témoin d'alerte qui permettrait de déceler rapidement des problèmes au sein des élevages.

Aussi, la situation de mauvaise technique d'abattage, la non ouverture de l'abattoir vers le modernisme doublée d'une gestion peu orthodoxe du service deviennent un handicap observable au quotidien. Une réflexion entre vétérinaire, professionnels de la viande et éleveurs pourrait permettre une amélioration des pratiques d'élevage.

## Conclusion

Au terme de cette étude qui s'est donnée comme objectifs de connaitre la fréquence de saisie, de déterminer les principaux motifs de celle-ci à l'abattoir municipal de Kousseri au cours des années allant de 2004 à 2014 et de janvier à juin 2017, l'analyse globale des résultats obtenus nous conduit aux conclusions suivantes :

- Les principaux motifs de saisie observés à l'abattoir municipal de Kousseri font payer un lourd tribut aux bovins, la tuberculose et la distomatose étant les motifs de saisie les plus importants ;
- Notre étude a révélé un cas de saisie totale de la carcasse due à la tuberculose ;
- Selon leur importance, les principaux motifs de saisie observés ont été la tuberculose, la distomatose, la pneumonie, les mammites, la cysticercose, la péricardite, les congestions, l'emphysème, la pleurésie et les abcès ;
- Sur le plan socio-économique, les principaux motifs de saisie ont entrainé des pertes considérables en protéines animales. Ces pertes en protéines, dans un pays qui en manque, montre à quel point les saisies sont préoccupantes.

## Recommandations

Au vu de nos conclusions, nous recommandons ce qui suit :

- Une vigilance collective et un autocontrôle dans le circuit de production de la viande ;
- Une amélioration des techniques d'abattage et des conditions d'élevage ;
- Une amélioration de l'inspection des viandes et abats ;
- Une amélioration des conditions de travail à l'abattoir municipal de Kousseri pour assurer une bonne préparation des viandes ;
- La mise en place d'une base de données statistique précise relative aux importations, à la production, aux déplacements d'animaux, aux abattages et aux saisies ;
- La mise en place d'un système d'indemnisation des bouchers pour alléger

les pertes dues aux saisies ;
- La lutte contre les pathologies animales récurrentes doit être maintenue et renforcée, et que celle contre les parasitoses soit systématisée ;
- Que tous les acteurs de la filière viande et les autorités administratives unissent leurs efforts pour la construction d'un abattoir moderne.

L'application rigoureuse de ces mesures pourrait conduire non pas nécessairement à l'éradication totale de pathologies observées, mais au moins, à une baise significative de leur incidence dans le cheptel et sur la santé humaine.
- La lutte contre les principaux motifs dominants de saisie afin d'augmenter les quantités de protéine disponibles pour la population et réduire les pertes engendrées.

Cette lutte sera largement compensée par une augmentation des quantités de viandes disponibles et par une amélioration de leur qualité hygiénique.

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# DIAGNOSTIQUE DE LA FILIÈRE APICOLE DANS QUATRE BASSINS DE PRODUCTION DU SÉNÉGAL : FORCES, FAIBLESSES, MENACES ET OPPORTUNITÉS

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## Résumé

Au Sénégal, comme partout en Afrique, l'apiculture est une branche de l'agriculture qui permet au monde rural de diversifier leurs activités génératrices de revenues en plus d'autres rôles joués par les abeilles dont la pollinisation et l'alerte à la dégradation de l'environnement. L'objectif de cette étude transversale était de faire un diagnostic de la filière apicole dans quatre bassins de production sénégalais afin de sensibiliser les décideurs et d'orienter les investisseurs. Ainsi, un questionnaire et un guide d'entretien descriptifs ont été administrés à 138 apiculteurs individuels et 32 groupements d'apiculteurs entre Septembre 2014 et janvier 2016. Les apiculteurs étaient à plus de 93,75 % des hommes âgés de 50 ans et plus (74,7%) avec de faibles connaissances sur les maladies des abeilles. Des disparités étaient également notées dans la modernisation de la filière. Le miel était le produit le plus exploité suivi de la cire à de très faibles proportions. Les apiculteurs de la région de Thiès sont modernes (100%) contrairement à ceux de Fatick et Vélingara où l'apiculture traditionnelle est encore pratiquée dans 9,7% et 91% des cas respectivement. Les faiblesses recensées sont d'ordres matériel, environnemental, technique et financière. Toutefois, nos zones d'étude restent propices à l'apiculture avec de multiples forces et opportunités.

**Mots clés :** apiculture, diagnostique, forces, faiblesse, Sénégal.

# BEEKEEPING VALUE CHAIN IN FOUR PRODUCTION BASINS IN SENEGAL: AN ANALYSIS OF OPPORTUNITIES AND WEAKNESSES

## Abstract

In Senegal as everywhere in Africa, apiculture is a branch of agriculture that can help people from rural and remote villages to diversify their activities and generate incomes. Honeybees are also involved in the pollination services process in agriculture and are a good indicator for environmental degradation. The aims of this cross-sectional study was to diagnose problems encountered by beekeepers in four production basins in Senegal, in order to guide policy makers and attract investment in the sector. A questionnaire and an interview guide were designed and distributed to 138 individual beekeepers and 32 groups of beekeepers between September 2014 and January 2016. Among the beekeepers surveyed (93.75%) were men aged more than 50 years and (74.7%) didn't have any knowledge about bee diseases. Modern beekeeping was unequally observed in the four basins. Beekeepers in the Thiès region were (100%) modern, compared to those of Fatick and Vélingara who were still doing traditional beekeeping at 9.7%

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and 91% respectively. Honey was the most preferred commodity followed by bee's wax. Lack of modern beekeeping equipment, climate change (environment) and funding were identified as major weaknesses. However, our study areas with the rich and diversified natural resources remain conducive to beekeeping.

**Key words:** Apiculture, diagnostic, weaknesses, strengths, Senegal.

## Introduction

L'apiculture partie intégrante de l'élevage est un secteur important de l'économie agricole, tant par le rôle joué par les populations d'abeilles dans la pollinisation que dans la production de miel et de ses sous-produits comme la cire, la propolis, la gelé royale etc., (Gerster, 2012).

En 2009, l'Institut National de la recherche Agronomique (INRA) a estimé à 153 milliards d'euro la valeur économique de la pollinisation effectuée par les abeilles soit 9,5% en valeur de l'ensemble de la production mondiale (Mollier *et al*., 2009). A cet effet, le service de pollinisation assuré par les abeilles est un bien commun entre les apiculteurs, les agriculteurs et la société tout entière (Gerster, 2012).

De plus, la sensibilité d'Apis mellifera (Linnaeus, 1758) aux variations des conditions environnementales permet de déceler les perturbations des écosystèmes, ce qui fait de cet insecte un sentinelle de l'environnement à caractère bio indicateur intéressant (Audusseau *et al*., 2008; Gerster, 2012). Selon, Audusseau (2008), de par sa domestication et à la vue des nombreux rôles remplis par l'abeille l'homme a le devoir de protéger cet insecte.

L'élevage est un secteur stratégique qui occupe près de 60% des ménages agricoles du Sénégal (ANSD, 2014), mais sa contribution à la richesse du pays est largement en deçà des attentes et objectifs fixés par le gouvernement en matière de sécurité alimentaire, (ANSD, 2016). Selon Mbahin (2017) avec 3150 tonnes de miel produit en 2012, le Sénégal est le 1er producteur de miel en Afrique de l'Ouest et 12ème au niveau continental. Diouf (2002) souligne que malgré les multiples actions de modernisation entreprises par le gouvernement du Sénégal depuis les années 1961, la filière apicole sénégalaise n'est pas bien métrisée et les actions de développement entreprises sont dirigées vers la production de miel uniquement. De ce fait, cette présente étude a pour objectifs de faire un diagnostic de la filière apicole afin d'identifier les obstacles majeurs entravant l'optimisation de la production apicole, d'attirer l'attention des décideurs et d'orienter les investisseurs pour booster la productivité apicole.

## Matériels et Méthode

*Zone d'étude*

L'étude a été menée dans quatre sites répartis dans trois régions à l'Ouest et su Sud du Sénégal. L'un des sites (Vélingara) se trouve dans la région de Kolda située au Sud et classée deuxième région apicole du pays. Cette région se caractérise par un climat de type soudano guinéen (Leroux,1983) avec une saison pluvieuse qui s'étale de juin à octobre et une saison sèche pour le reste de l'année. La moyenne pluviométrique varie entre 700 et 1300 mm avec des températures qui oscillent entre 25 et 40°C (ANSD/SRSD Kolda, 2010).

Le site de Toubacouta situé dans la région de Fatick, la zone des Niayes et Bandia/village, dans la région de Thiès, sont tous situés à l'Ouest du pays et se caractérisent par un climat de type Sub-canarien (Leroux,1983) puis une alternance d'une saison sèche longue de neuf mois (d'Octobre à Juin) et une saison pluvieuse de trois mois (Juillet à Septembre) seulement. A Toubacouta, les températures varient entre 20 et 45°c et la moyenne annuelle pluviométrique est de 871,45mm. La zone des Niayes et Bandia/village enregistrent des précipitations peu abondantes (350 mm en moyenne) mais étant sous l'influence des alizés maritimes bénéficient de températures modérées dépassant rarement 30°C (Camara, 2010 ; Diop, 2013) (Figure 1).




**Figure 1 :** Carte de localisation des zones d'étude

*Collecte et analyse des données*

Cette étude transversale s'est déroulée entre Septembre 2014 et Janvier 2016 et les informations ont été recueillies auprès de 138 apiculteurs individuels et 32 organisations d'apiculteurs. En l'absence de données précises sur le nombre d'apiculteurs individuels et de groupements existant dans les zones d'étude, le choix des individus et groupements interviewés s'est fait grâce aux informations reçues aux près des consultants en apicultures et des organisations encadrant les apiculteurs (liste de localités ou est pratiquées l'apiculture et parfois même des identités d'apiculteurs, Noms d'organisations d'apiculteurs…). Les informations ont été recueillies à travers des entretiens individuels et des focus groupes respectivement à l'aide d'un questionnaire et un guide d'entretien descriptifs respectivement pour les apiculteurs individuels et les groupements d'apiculteurs. Elles concernaient entre autres, les données socio-démographiques, les modes de production, le niveau de formation, les contraintes liées à l'activité et les perspectives). En plus, nous avons tenu des interviews directes et recueilli des informations auprès de 21 représentants de structures et ONGs évoluant dans la filière apicole au niveau de nos zones d'étude.

Les données recueillies ont été saisies puis traitées avec le logiciel Epi info 200 version 3.5.4 (CDC, 2012), ce qui a permis d'obtenir les statistiques descriptives et les graphiques ont été réalisés à l'aide de Microsoft Excel 2016.

## Résultats

*Données socio-démographiques des enquêtés*

Les résultats ont montré que, les apiculteurs individuels étaient constitués uniquement d'hommes âgés en moyenne de 49 ans et étaient en majorités (74,70%) des personnes vieilles de plus de 50 ans (Figure 2). Les femmes avaient été retrouvées seulement dans deux groupements enquêtés sur les 32. Elles représentaient 6,25% contre 93,75% d'hommes. Les activités principales des apiculteurs sont très diversifiées avec une très forte proportion (86,20%) d'agriculteurs contre seulement 9,40% ayant comme activité principale l'apiculture (Figure 3). A Vélingara (Kolda), sur les 12 groupements enquêtés seuls trois (25%) étaient juridiquement formels. En revanche, à Toubacouta (Fatick), 11/14 (78.57%) et à Thiès, 4/6 (66,66%) avaient un statue juridique formel.

*Les pratiques apicoles*

L'expérience des apiculteurs individuels dans l'activité variait entre 1 et 50 ans de pratique avec une moyenne de 20 ans. Les groupements d'apiculteurs avaient une expérience comprise entre 1 et 29 ans avec une moyenne de 9,5 ans (Tableaux 1 et 2).

Les résultats de l'enquête avaient montré que globalement l'apiculture traditionnelle était encore pratiquée à Toubacouta et Vélingara. Dans ces zones, les apiculteurs individuels modernes ne représentaient que respectivement 74,2% et 4% des échantillons considérés. Nous avions également retrouvé 40% de chasseurs de miel à Vélingara ; quant aux groupements d'apiculteurs, 16,70% pratiquaient l'apiculture traditionnelle et 25% alliaient traditionnelle et moderne (c'est-à-dire mixte) dans ce site. Dans les régions de Fatick et Thiès par contre, les groupements pratiquaient à 100% de l'apiculture moderne (Figure 4).

L'utilisation des produits chimiques dans l'activité apicole se limitait essentiellement à l'entretien du matériel apicole et aux « attire essaims ».

**Tableau 1:** Ancienneté des apiculteurs individuels dans la profession

| Trans d'âge | Fréquence | Pourcentage (%) |
|---|---|---|
| 1-10 ans | 44 | 31,88 |
| 11-20 ans | 45 | 32,61 |
| 21 ans et plus | 49 | 35,51 |
| **Total** | **138** | **100** |
| **Minimum 1an** | **Moyenne 19,75 ans** | **Maximum 50 ans** |

**Tableau 2:** Ancienneté des groupements d'apiculteurs dans la profession

| Expérience | Nombre | Pourcentage (%) |
|---|---|---|
| 1-5 ans | 12 | 37,5 |
| 6-10 ans | 9 | 28,1 |
| 11-15 ans | 5 | 15,6 |
| 16-20 ans | 4 | 12,5 |
| 21-30 ans | 2 | 6,3 |
| **Total** | **32** | **100,0** |
| **Minimum= 1 an** | **Moyenne = 19,75 ans** | **Maximum = 50 ans** |

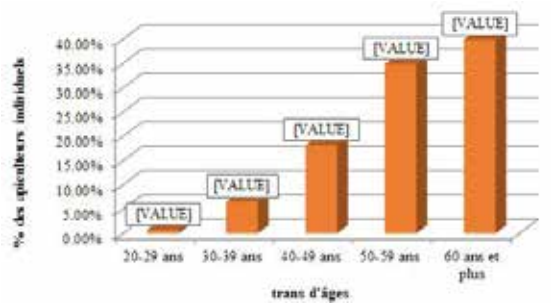
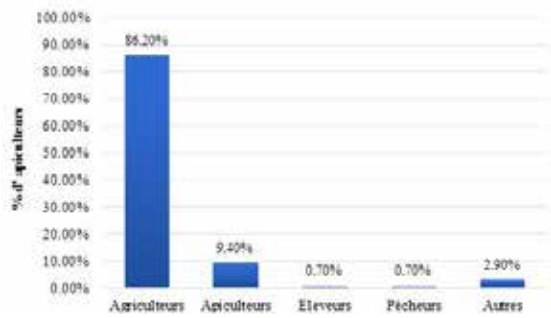



**Figure 2 :** Tranches d'âge des apiculteurs individuels enquêtés




**Autres = Bouchers, Commerçant, Employé des eaux et forêts, Ancien chauffeur, Grillot, Imam, Jardinier, Peintre.*

**Figure 3:** Répartition des apiculteurs selon leur profession principale

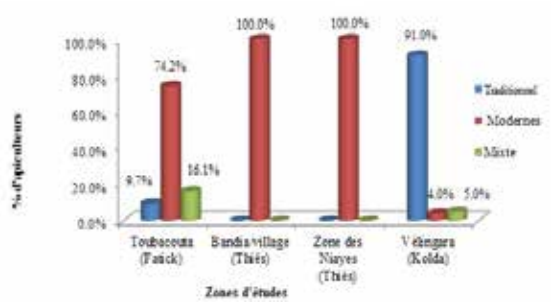
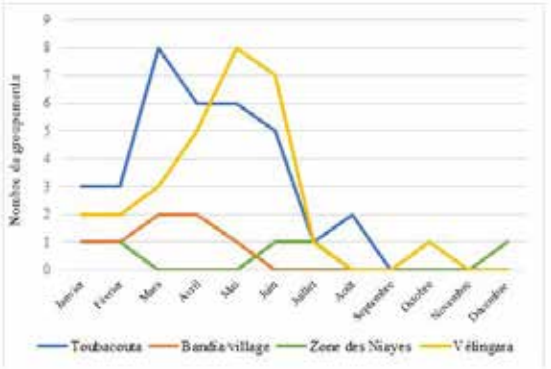
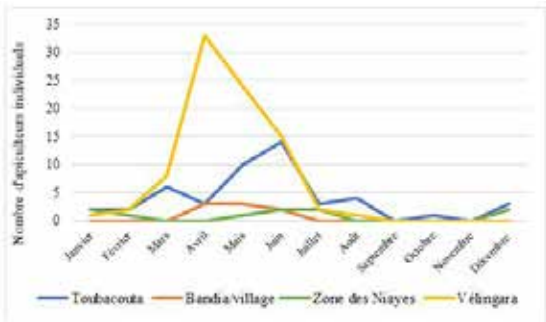



**Figure 4:** Modes d'apiculture pratiqués par les apiculteurs individuels selon le site




a : organisations d'apiculteurs




b: Apiculteurs individuels

**Figure 5:** Périodes de récolte du miel chez les organisations d'apiculteurs et agriculteurs individuels selon le site

*Exploitation des produits apicoles*

Le miel était le principal produit exploité par les apiculteurs (100%) suivi secondairement de la cire exploitée à de faibles proportions (Tableau 3). En outre les apiculteurs de la région de Thiès effectuent aussi la location de ruches pour le service pollinisation.

L'installation des ruches se faisait sur 4 mois (novembre, janvier, février, mai) chez les organisations d'apiculteurs, et sur 8 mois (Octobre à mai, le mois d'Avril non compris). Toute fois, la récolte du miel se faisait de janvier à juillet selon les sites et le nombre de récoltes annuelle par ruche était en moyenne de 2 chez les organisations et 1 pour les apiculteurs individuels (Figure 5).

Par ailleurs, la taille moyenne des ruchers était de 14 ruches chez les apiculteurs individuels et 43,51 chez les groupements.

*Niveaux de connaissances des apiculteurs*

Les proportions moyennes d'apiculteurs formé étaient de 3 dans la région de Thiès ; 2,5 à Toubacouta et 1,8 à Vélingara. La presque totalité des apiculteurs soient 80% des apiculteurs individuels et 88% des groupements d'apiculteurs étaient conscients de l'utilité des abeilles pour l'environnement, alors que seul 10% et 31% des apiculteurs individuels et organisations d'apiculteurs respectivement affirmaient connaitre les maladies des abeilles.

Les paramètres susceptibles d'influencé la production apicole dans le cadre de notre étude sont résumés dans le tableau 4.

*Contraintes inhérentes à la production apicole et opportunités*

Des contraintes de natures très diversifiées qui inhibent la production apicole ainsi que les perspectives qui résultent des enquêtes et des entretiens sont répertoriées dans le tableau 5 sous formes de tableau des Forces, Faiblesses, Opportunités et Menaces (FFOM).

## Discussion

Cette étude sur l'apiculture au Sénégal avait pour objectif de faire le point sur l'état de l'activité apicole afin d'identifier et de sensibiliser les pouvoirs publics sur les obstacles majeurs qui entravent le développement de la filière, orienter les investissements et stimuler la production.

Les résultats ont montré que les femmes étaient très faiblement représentées (6,25% des groupements) dans l'apiculture. Ces résultats sont similaires à ceux trouvés au Sénégal par Diouf (2002), dans les hautes terres de l'Ouest Cameroun par Tchoumboue (2001), et au Nord-Ouest du Bénin par Ahouandjinou (2016) et Paraïso (2017). Ces auteurs avaient noté que l'apiculture est essentiellement pratiquée par les hommes et les femmes représentent moins de 10% des populations enquêtées. En Somali Regional State (Ethiopie), Fikru *et al.* (2015) avaient observé que100% des apiculteurs interrogés étaient des hommes tandis qu'en Bourgogne (France), Adrien *et al.* (2014) avaient noté 86,8% d'hommes.

Nos résultats étaient cependant contraires à ceux rapportés par Kenmogne *et al* (2014) dans la région de l'Ouest- Cameroun, par Abera *et al*., (2016) ; Gebretsadik et Negash, (2016) en Ethiopie et par Niyonsenga (2016) au Rwanda où les femmes représentent respectivement 20%, 16% et 23,8% des apiculteurs enquêtés.

Par ailleurs, ces études ont toutes montré que la représentation des femmes est loin d'égaler la moitié de celle des hommes. Cela pourrait être dû à un aspect culturel où encore s'expliquer par le fait que l'apiculture traditionnelle étant pratiquée très souvent

la nuit et les ruches souvent accrochées sur les arbres était ainsi considérée comme une activité plus adaptée aux hommes. Par ailleurs, bien que faible, cette représentation féminine peut être considérée comme un progrès lié à l'avènement de l'apiculture moderne.

La moyenne d'âge de la population des apiculteurs que nous avons trouvé dans le cadre de cette étude (49 ans) était proche de celle signalée par Yédomonhan (2009) au Bénin à Manigri (50 ans), Kenmogne *et al*. (2014) au Cameroun (50 ans) et Lamaignere (2001) en Nouvelle-Calédonie (52,5 ans). En Bourgogne aussi, la classe d'âge des 54 ans et plus était la plus représentée avec 39,5 % des apiculteurs, (Adrien *et al*, 2014). Dans toutes ces régions citées ci-dessus, l'apiculture était pratiquée en majorité par une population vieillissante.

Cependant l'âge moyen (30 ans) des apiculteurs relevés par Gebretsadik et Negash, (2016) en Ethiopie était inférieur à ceux signalés plus haut. Une autre étude menée dans le même pays avait aussi montré que 50% des apiculteurs interrogés avaient un âge compris entre 30 at 39 ans (Abera, 2016) alors que 74,7% de notre population d'étude avait plus de 50 ans. Au Togo également, 58,62% des apiculteurs interrogés avait moins de 50 ans (Sokemawu 2015) et au Bénin, la moyenne d'âge était de 35,75 ans (Paraïso 2017). Ceci témoigne de l'intérêt que les jeunes portent à l'apiculture en Ethiopie, au Togo et au Sud du Bénin. Ainsi, cela montre qu'il est nécessaire d'intégrer d'avantage les femmes et d'intéresser les jeunes à cette activité source de revenus supplémentaires et d'occupation.

L'expérience moyenne des apiculteurs éthiopiens dans l'activité était de quatre ans, alors que notre population d'étude au Sénégal avait une expérience moyenne de 9 ans et 20 ans pour les organisations et les apiculteurs individuels respectivement. Nos résultats diffèrent également de ceux de Tchoumboue (2001) qui souligne que près de la moitié de sa population d'étude avait moins de 5 ans d'expérience. Ceci montre que l'apiculture est une activité très ancienne au Sénégal qui mérite d'être développé davantage compte tenu de l'expérience accumulée su fil des années.

Les activités principales des apiculteurs étaient très diversifiées avec une très forte proportion d'agriculteurs (86,20%). Nos résultats confirment ceux de Diouf (2002) qui avait trouvé que 85% des apiculteurs interrogés au Sénégal avaient comme activité principale l'agriculture. Ils étaient aussi similaires à ceux trouvés au Bénin par Yédomonhan (2009) et Paraïso (20017) où l'ensemble des apiculteurs enquêtés avaient comme activité principale l'agriculture. A l'Ouest du Cameroun, Tchoumboue (2001) avait montré que la majorité des apiculteurs était des fonctionnaires (16,3%) et des collégiens (5,4%). En Outre ceci est également valable au Togo avec 58,92% d'agriculteurs trouvés par (Sokemawu, 2015). Cela confirme que l'apiculture est certe une activité secondaire en générale mais qui peut être pratiquer par tous quelque soit l'activité principale de l'individu. Le pourcentage (86,20%) d'agriculteurs-apiculteurs s'expliquerait par le fait que l'apiculture est utilisée comme activité pourvoyeuses d'emplois et génératrice de revenues en saison sèche. Ainsi, sans le savoir, les agriculteurs préservent les abeilles pour le service de pollinisation si précieux et gratuit pour la conservation de la biodiversité.

Les résultats du tableau 3 ont montré que l'exploitation de la cire était très faible voir inexistante dans certaines zones d'étude et était pratiqué seulement par les groupements d'apiculteurs. Cela pourrait s'expliquer soit par le manque de formation sur le traitement de la cire ou à la faible quantité obtenue après la récolte mais également à un manque d'intérêt à cet important produit de la ruche. On observe aussi l'inexistence des autres produits de la ruches (pollens, propolis, gelé royal, le venin d'abeille etc.). Ainsi, la sensibilisation et la formation sur l'importance de la cire et des autres produits s'avère être une nécessité urgente.

Dans nos zones d'étude, la récolte comme la pose des ruches par les détenteurs de ruches traditionnelles se faisaient pendant la saison sèche. Toutefois, plus de 50% des apiculteurs récoltaient entre Avril et Mai. Cela pourrait s'expliquer par le fait que les ruches sont en majorité en paille et ne peut résister

**Tableau 3:** Production moyenne annuelle (kg) de miel et de cire par groupement d'apiculteur de 2011 à 2014

| Production miel et cire (Kg) /Années Zones d'étude | 2011 | | 2012 | | 2013 | | 2014 | |
|---|---|---|---|---|---|---|---|---|
| | Miel | Cire | Miel | Cire | Miel | Cire | Miel | Cire |
| Toubacouta | 27,28 | 4,67 | 52,42 | 3,00 | 68,22 | 1,33 | 201,12 | 2,25 |
| | (34,87) | (6,30) | (74,06) | (0,00) | (98,19) | (0,58) | (430,46) | (1,89) |
| Bandia/village | ND | 0,00 | 355,67 | 0 ,00 | 3130 | 0,00 | 1353,50 | 0,00 |
| | | (0,00) | (151,48) | (0 ,00) | (0,00) | (0,00) | (1744,43) | (0,00) |
| Zone des Niayes | 1907,50 | 0,00 | 1132,50 | 0,00 | 3130 | 0,00 | 1353,50 | 73,00 |
| | (2273,35) | (0 ,00) | (1443,20) | (0 ,00) | (0,00) | (0,00) | (1744,43) | (0,00) |
| Vélingara | 648,33 | 55,00 | 227,14 | 41,67 | 371,78 | 37,75 | 484,17 | ND |
| | (947,15) | (0,00) | (348,39) | (31,75) | (540,21) | (21,30) | (663,75) | |

*ND = Non déterminé ; () = Ecart-type*

**Tableau 4:** Paramètres influençant la production apicole en fonction du site

| Paramètres | Caractéristiques | Toubacouta (Fatick) | | Bandia/village (Thies) | | Zone des Niayes (Thies) | | Vélingara (Kolda) | |
|---|---|---|---|---|---|---|---|---|---|
| | | Gpt. Ap (N=14) | Ap. Ind. (N=3) | Gpt. Ap. (N=4) | Ap. Ind (N=4) | Gpt. Ap. (N=2) | Ap. Ind. (N=3) | Gpt. Ap. (N=12) | Ap. Ind (N=100) |
| Nombre de formations/ apiculteur | Minimum | 1 | 1 | 2 | 2 | 2 | 3 | 1 | 1 |
| | Moyenne | 3,50 (1,33) | 2,55 (1,47) | 4,25 (1,50) | 3,75 (1,50) | 2,50 (0,71) | 3,00 (0,00) | 2,00 (0,89) | 1,81 (1,04) |
| | Maximum | 8 | 7 | 5 | 5 | 3 | 3 | 4 | 5 |
| Taille rucher/ groupement | Minimum | 8 | 1 | 17 | 5 | 35 | 2 | 10 | 2 |
| | Nombre moyen de ruches | 39,07 (39,17) | 7,31 (6,78) | 23,00 (5,71) | 11,25 (8,09) | 42,50 (10,61) | 7,33 (4,62) | 69,50 (60,34) | 17,69 (13,20) |
| | Maximum | 150 | 32 | 30 | 23 | 50 | 10 | 200 | 74 |
| Types de ruches/ apiculteur | Modernes (moyenne) | 36,21 (39,77) | 5,65 (5,20) | 23,00 (5,71) | 11,25 (8,09) | 41,00 (12,72) | 7,33 (4,62) | 45,50 (62,73) | 1,34 (4,05) |
| | Traditionnelles (moyenne) | 0,00 (0,00) | 1,59 (4,62) | 0,00 (0,00) | 0,00 (0,00) | 0,00 (0,00) | 0,00 (0,00) | 11,30 (22,45) | 16,39 (14,06) |
| Nombre de récoltes/ annuelle/ruche | Moyen de récolte/ ruche | 1,78 (0,69) | 1,45 (0,51) | 1,75 (0,50) | 1,25 (0,50) | 2,00 (0,00) | 1,67 (0,58) | 1,58 (0,90) | 1,44 (1,72) |
| | Maximum | 3 | 2 | 2 | 2 | 2 | 2 | 4 | 2 |
| Connaissance du rôle des abeilles dans l'Environnement | Oui | 78,60% | 93,50% | 100% | 100% | 100% | 100% | 100% | 69,00% |
| | Non | 21,40% | 6,50% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 31,00% |
| Connaissance sur les maladies des abeilles | Oui | 42,90% | 22,60% | 50,00% | 0,00% | 100% | 66,70% | 0,00% | 5,00% |
| | Non | 57,10% | 77,40% | 50,00% | 100% | 0,00% | 33,30% | 100% | 95,00% |
| Lieu vente du miel | Dans le village | 77,27% | 75,00% | 77,78% | 50,00% | 100% | 61,00% | 72,42% | 55,30% |
| | ONGs, Privés ou Grandes surfaces | 18,18% | 14,00% | 22,22% | 50,00% | 0,00% | 0,00% | 13,79% | 9,70% |
| | Marchés | 4,55% | 11,00% | 0,00% | 0,00% | 0,00% | 34,00% | 17,24% | 35,00% |

*NB: Gpt. Ap. = Groupement d'apiculteurs ; Ap. Ind = Apiculteur Individuel ; N= Nombre d'enquêtés par site ; () = Ecart - type*

**Tableau 5:** Analyse FFOM / SWOT du secteur apicole

| | |
|---|---|
| **Forces :** | **Opportunités :** |
| • Biodiversité : ressources naturelles riches et diversifiées,<br>• Utilisation réduite des produits chimiques dans l'activité apicole.<br>• Existence de plusieurs projets dans le domaine<br>• Modernisation de la filière en cours<br>• Diversité et abondance des plantes mellifères<br>• Intervention mécanique (sans usage de produits chimiques) en cas d'attaque des ruches | • Existence de la plateforme des acteurs de la filière apicole<br>• Début d'organisation des apiculteurs en groupements<br>• Présence de nombreux organismes et acteurs qui appuient la filière<br>• Moins de dommages liés aux maladies d'abeilles<br>• Résistance des abeilles à leurs maladies |
| **Faiblesses :** | **Menaces :** |
| • Faible représentativité des jeunes dans la filière<br>• Faible représentativité des femmes dans la filière<br>• Usage de matériels apicole traditionnel<br>• Défaut de réglementation nationale<br>• Activité non encore prise en compte par le système de crédit<br>• Difficultés de financement de la filière apicole<br>• Répétitions des thèmes de formation<br>• Manque de financement de la recherche<br>• Insuffisance de la formalisation<br>• Manque de coordination entre ONG et structures étatiques évoluant dans le domaine<br>• Mauvaises pratiques de récolte (usage du feu lors de la récolte du miel, etc.)<br>• Non maîtrise du circuit de commercialisation<br>• Enclavement des zones de production<br>• Disparités dans la modernisation<br>• Insuffisance de matériel et infrastructures apicole (48% des contraintes notées)<br>• Caractère saisonnier de l'activité<br>• Non exploitation des autres produits de la ruche | • Désertion des ruches (52%) pour les apiculteurs individuels et 58% chez les organisations d'apiculteurs)<br>• Réduction de la taille des colonies d'abeilles<br>• Présence des prédateurs (79% ; 65% ; 33% et 68%) dans les quatre sites<br>• Insuffisance de techniciens spécialisés<br>• Pratique de l'activité par une population vieillissante<br>• Concurrence entre acteurs<br>• Forte utilisation des pesticides dans l'agriculture<br>• Déforestation (abattage des arbres mellifères)<br>• Mauvaise connaissance des prédateurs des abeilles<br>• Mauvaise connaissance des pathologies des abeilles<br>• Vol de ruches<br>• Raréfaction des colonies d'abeilles<br>• Manque de sensibilisation de certaines personnes qui crée un environnement défavorable à l'apiculture |

à la pluie. Le mois de Mai correspond à la période d'essaimage. La période de récolte de notre population d'étude concordait avec celle des apiculteurs de Togo Sokemawu (2015) et du Cameroun Tchoumboue (2001), mais la période d'installation des ruches (Septembre à Mars) était plus longue pour ceux du Cameroun. Les périodes d'installation des ruches et de récolte du miel mentionnées par les apiculteurs rencontrés dans notre étude recoupent certes celles relatées par Diouf (2002) mais étaient plus longues. Cela pourrait se justifier par un plus grand intérêt accordé à l'activité mais aussi à la formation reçue ou à la raréfaction des colonies d'abeilles constatée par les apiculteurs. En outre, le fait que les périodes de récolte différées d'un site à l'autre pourraient être considérer comme un atout car cela montre qu'il serait possible d'avoir du miel durant une bonne partie de l'année. Par ailleurs, il conviendrait d'introduire les nouvelles technologies comme l'élevage des reines et la multiplication des colonies dans toutes les zones apicoles.

Le tableau 4 montre que le niveau de formation varie d'un site à l'autre. En plus, les organisations d'apiculteurs ont reçu plus de formations que les apiculteurs individuels et

qu'il existe un manque de connaissances sur les maladies des abeilles. Ceci pourrait être lié à un déficit de formation ou de vulgarisateurs sur ce sujet dans la zone. Ainsi, il apparait indispensable de vulgariser les connaissances déjà acquises au près des autres apiculteurs par le partage de connaissances entre apiculteurs.

Les résultats de cette étude ont également montré que malgré le nombre important de structures et de projets évoluant dans le domaine de l'apiculture, il existe des disparités dans la modernisation de cette filaire au Sénégal.

Le tableau 4 montrait que les organisations d'apiculteurs disposaient de plus de ruches modernes que les apiculteurs individuels. Les apiculteurs de la région de Thiès (Bandia/village et Zone des Niayes) sont de loin les plus modernes (100%) suivis de ceux de Fatick (Toubacouta) et de Kolda (Vélingara) où l'apiculture traditionnelle était encore pratiquée. Ces disparités pourraient être dues à la faible organisation des apiculteurs de Vélingara qui rend difficile l'acquisition des ruches modernes mais aussi à l'enclavement des sites de production. En ce référent à la classification des apiculteurs en France, seul un groupement d'apiculteur détenait 200 ruches et donc pouvait être considéré comme professionnel dans le cadre de cette étude. En revanche, si on tient compte de celle de l'Union Européenne on pouvait noter deux groupements professionnels (détenteurs de 150 ruches et plus). Chez les apiculteurs individuels on ne trouvait que des producteurs familiaux (détenteurs de 1 à 30 ruches) et pluriactifs (détenteurs de 30 à 150 ruches).

Le matériel de traitement de miel traditionnel était encore rencontré à Vélingara auprès des organisations d'apiculteurs à hauteur de (80%) contre 20% de moderne. Cependant il était à 100% moderne dans les autres sites. Les apiculteurs individuels eux n'en disposaient pas du tout. Après récolte, le miel était acheminé chez les organisations d'apiculteurs pour le traitement, ce qui témoigne de la nécessité d'organisation au sein de la filière. Toutefois en Afrique, on note une nette amélioration (modernisation) du secteur avec le nombre de ruches modernes actuellement utilisées par rapport à celles répertoriées par Hussein (2001). Dans le cadre de cette étude, le nombre moyen de ruches (14) que détenait un apiculteur individuel était inférieur à celui trouvé par Ndola (2014) en République Démocratique du Congo (RDC) mais proche de la moyenne détenue par les organisations d'apiculteurs. Sur ce sujet, nos résultats étaient très différents de ceux trouvés par Abera (2016) en Ethiopie avec seulement un total de 200 ruches traditionnelles, 70 ruches intermédiaires et moins de 25 ruches modernes recensées dans la zone d'étude. Ainsi, nous invitons les apiculteurs individuels à rejoindre les groupements d'apiculteurs déjà existants ou de s'associer en nouvelles organisations d'apiculteurs afin de bénéficier des ruches et de matériel de traitement de miel moderne.

La majorité des apiculteurs écoulaient leur production dans leurs villages sans se déplacer, ce qui pose un problème pour les villages enclavés. Nous avons noté également que les ONGs et les Privés devenaient des clients potentiels et la vente dans les marchés était en régression, ce qui constitue un progrès non négligeable. Certains apiculteurs envoyaient leur production à l'intérieure du pays et d'autres dans les cités religieuses lors des grandes rencontres ou cérémonies religieuses pour écouler leur production. C'est le cas à Kolda avec le « Daaka » de Médina Gounas et à Touba lors du « Magal ». Comme l'a indiqué Diouf (2002), les apiculteurs avaient plusieurs voies pour écouler leur production.

Les faiblesses et menaces évoquées par nos apiculteurs ont été également soulignées dans d'autres pays par Tchoumboue (2001) ; Kenmogne *et all* (2014) ; Ndola (2014) ; Ahouandjinou (2016) et Gebretsadik et Negash (2016).

## Conclusion

En conclusion, cette étude a permis de faire un diagnostic assez large de la filière dans les zones d'étude. Il apparaitrait que bien qu'étant une activité secondaire, l'apiculture

est une pratique très ancienne effectuée en grande partie par les hommes en particulier des personnes âgées. Ceci montre la nécessité d'intégrer l'aspect genre et d'intéresser les jeunes à cette filière. Malgré l'existence de multiples sous produits de la ruche sources de revenues, seul le miel est exploité par les apiculteurs. A la vue de la richesse de la biodiversité des zones d'études, et des efforts consentis par l'Etat pour booster le secteur, cette production est encore très faible par rapport aux potentialités existantes, d'où la nécessité de moderniser d'avantage le matériel de production. En outre, avec la présence de l'apiculture traditionnelle dans certaines zones, le regroupement des apiculteurs individuels en organisation s'avère nécessaire et le renforcement des capacités des apiculteurs en particulier sur la santé des abeilles indispensable. A cet effet, une synergie entre les acteurs qui s'inscrit dans une démarche globale de dynamisation de la filière s'avère indispensable.

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# FORMULE DE BARYMETRIE POUR L'ESTIMATION DU POIDS CHEZ LES ZEBUS GOUDALI AU CAMEROUN

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## Résumé

L'appréciation des performances pondérales des bovins est souvent impossible à des circonstances diverses au Cameroun à cause du manque de bascule pèse-bétail. L'estimation du poids d'un animal de façon visuelle est parfois envisagée par les acteurs de la filière *bovine*. La barymétrie peut être un moyen plus simple et d'un secours objectif pour estimer le poids des animaux en l'absence de bascule pèse-bétail. L'objectif de cette étude a été de déterminer une équation barymétrique d'estimation du poids des zébus Goudali, le meilleur type de bétail de boucherie que possède le Cameroun. Dix mensurations corporelles et des pesées simultanées ont été effectuées sur 340 zébus Goudali de type Ngaoundéré élevés en stations près de la ville de Ngaoundéré, Région de l'Adamaoua au Cameroun. Au total 630 équations de régression linéaire ont été étudiées pour identifier celles présentant une meilleure prédiction du poids chez l'ensemble des animaux (mâles et femelles). La régression curvilinéaire utilisant le périmètre thoracique comme variable indépendante s'est révélée la meilleure équation de prédiction du poids chez toutes les catégories d'âge et de sexe des zébus Goudali de Ngaoundéré: $Y = 0{,}00016004^{1}X^{2{,}8467}$, $r2 = 0{,}9701$. Cette équation barymétrique a permis d'établir une table de conversion du périmètre thoracique en poids. Ce travail constitue une base de données pour la confection d'un ruban barymétrique d'estimation du poids du zébu Goudali de Ngaoundéré.

**Mots Clés:** Poids; barymétrie; mensuration; périmètre thoracique; Goudali; Ngaoundéré

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## Introduction

Le Cameroun possède un cheptel bovin estimé à plus de cinq millions de têtes réparties principalement dans les trois régions septentrionales (Adamaoua, Nord et Extrême-Nord), le Nord-Ouest et l'Est du pays (MINEPIA, 2015). Les types raciaux principaux sont les zébus (Bos indicus) Peuls, Arabes Choa, Massa/Toupouri, des races résiduelles de taurins (Bos taurus) autochtones (Kapsiki, namshi, Kouri, Bakossi), des produits de métissage entre différents types de bovins et quelques taurins importés (Messine *et al*., 1995). Si les autres types de bovins (Arabes Choa, Massa/Toupouri et taurins autochtones) sont non moins importants en termes économiques et culturels pour les groupes ethniques qui les élèvent, en général au Nord et à l'Extrême-Nord du Cameroun, le cheptel bovin camerounais dans son ensemble est constitué en majeur partie de zébus Peuls qui se subdivisent en zébus Mbororos et Foulbés tels que décrit par Mandon (1953) et Lhoste (1969). En bref, les zébus Mbororo sont constitués de trois sous-types: Mbororo Djaafoun ou zébus rouge, Mbororo Akou ou zébus blancs et Mbororo Woodabé, intermédiaire entre les zébus Djaafoun et les Akou, mais peu représentés au Cameroun (Mandon, 1953; Lhoste (1969). Les zébus Foulbés rencontrés sur le plateau de l'Adamaoua camerounais comprennent également trois variétés selon des aires de prédilection distinctes: Goudali de Ngaoundéré, Goudali de Banyo et Goudali de Yola (Lhoste, 1969). Le Goudali de l'Adamaoua camerounais serait apparenté au zébu Sokoto du Nigeria (Messine *et al*., 1995). La variété de bovin Goudali de Ngaoundéré a été décrite et considérée par de multiples études comme le meilleur type de bétail de boucherie que possède le Cameroun (Mandon, 1957 ; Lhoste, 1969 ; Messine *et al*., 1995 ; Crimella *et al*., 2003). C'est l'unique race d'animaux domestiques du Cameroun à avoir une description officielle consacrée par un arrêté du Ministère de l'Elevage des Pêches et des Industries Animale du Cameroun (MINEPIA, 1994). Cet arrêté crée un « Herd Book de Goudali» où doivent être inscrits les plus beaux spécimens issus des opérations de sélection de cette race. Toutefois ce Herd-Book n'a jamais connu une association d'éleveurs pouvant faire l'amélioration et la promotion génétique du zébu Goudali de Ngaoundéré. Ce registre de standard du zébu Goudali est confié à la Station Zootechnique de WAKWA près de Ngaoundéré dans la Région de l'Adamaoua au Cameroun, en attendant la création d'un groupement d'éleveurs opérationnel de cette race.

Dans la masse importante des données publiées sur le bovin Goudali de Ngaoundéré, la barymétrie comme méthode simple d'estimation du poids des bovins à des circonstances diverses où il y a manque de bascule-pèse bétail est inexistante. Par contre des investigations détaillées ont été faites pour déterminer des formules barymétriques pouvant estimer le poids des autres zébus de l'Afrique de l'Ouest tels que les zébus Gobra et Azawak (Chollou *et al*., 1978 ; Dodo *et al*., 2001 ; Touré *et al*., 2017) et divers types de taurins Ouest-Africains y compris les taurins autochtones du Cameroun (Poivey *et al*., 1980 ; Bulgen *et al*., 1984; Dineur et Thys, 1986 ; Symoens et Hounsou, 1991). Au Cameroun dans les diverses circonstances de la filière *bovine* où le Goudali à une place prépondérante (exploitations *bovine*s, marchés à bétail, lieux d'abattage), il est impossible d'avoir des données pondérales sur les animaux. A de multiples occasions où il est nécessaire de connaître le poids (la masse en kilogrammes) de l'animal, un poids approximatif est donné par simple appréciation visuelle. Cette appréciation visuelle subjective du poids d'un bovin constitue une source d'erreurs significatives inévitables. C'est le cas, par exemple, où il faut déterminer la quantité de médicament à administrer à un animal malade en fonction de son poids (la dose de médicament). C'est aussi les cas dans les foires à bétail organisées annuellement à Ngaoundéré et où il faut classer les bovins Goudali mis en compétition suivant des critères objectifs parmi lesquels le poids de l'animal. L'objectif de cette étude a été de déterminer des équations barymétriques utilisables en milieux variés d'élevage, de vente

et d'abattage du zébu Goudali au Cameroun où une bascule-pèse-bétail peut être absente.

## Matériel et Méthodes

*Sites d'étude*

L'étude s'est déroulée du mois d'Août au mois d'Octobre 2016 sur les troupeaux bovins de la station de l'Institut de Recherche Agricole pour le Développement (IRAD) de Wakwa du Ministère de la Recherche Scientifique et de l'Innovation et de la Station Zootechnique de Wakwa du Ministère de l'Elevage des Pêches et des Industries Animale du Cameroun. Les deux stations, très proches l'une de l'autre, sont situées à environ 12 km de la ville de Ngaoundéré (7°30' de latitude Nord et 13°30' de longitude Est) sur le plateau de l'Adamaoua Camerounais. Le relief n'est pas uniforme et on note une altitude moyenne de 1200 m. Le climat est de type soudano-guinéen à deux saisons : une saison sèche et une saison pluvieuse. La saison sèche dure en moyenne 5 mois (de Novembre à Mars). Le reste de l'année, d'Avril à Octobre, est pluvieux avec des précipitations annuelles pouvant atteindre 1800 mm. Les températures annuelles oscillent entre 23 et 32° C. Le couvert végétal est constitué de formations herbeuses (diverses graminées tropicales), de savanes arbustives et arborées claires (Mbogning *et al*., 2011).

*Description de l'animal*

Le zébu Goudali, type Ngaoundéré (Figure 1, Figure 2) est caractérisé par une taille moyenne (hauteur au garrot en moyenne 130 cm chez le mâle et 120 cm chez la femelle), un profil convexe, un bassin incliné et des membres postérieurs dressés (Mandon, 1957; Lhoste, 1969). La bosse, une production mi-musculaire et mi-graisseuse qui, s'étant développée au dépend du muscle rhomboïde, fait saillie dans la région du garrot en position thoracique où elle est, chez la majorité des animaux très développée et tombante (Mandon, 1953; Lhoste, 1969). Cependant, la masse de cette bosse, son volume ou sa circonférence n'ont pas été décrite en détail. Le cornage est court et fin et l'encolure courte et plate. Le fanon est développé et le fourreau est en général pendant. Le squelette léger et le bon développement des masses musculaires de l'arrière main confèrent à ce zébu une conformation bouchère satisfaisante. La race n'étant pas véritablement fixée, il y a de nombreuses variations quant au poids ou au format (Lhoste, 1969 ; Crimella *et al*.,1995). L'animal peut atteindre un poids adulte de plus de 550 kg (voire 900 kg à 8 ans d'âge chez les mâles) et 350 kg ( voire 500 kg à 7 ans chez les femelles) avec un rendement en boucherie supérieure 50 % (Mandon, 1953; Lhoste, 1969). La race a une robe caractéristique pie-rouge (Figure 1, Figure 2). On rencontre également des robes suivantes : brune, pie-noire, froment, rouge acajou, fauve et noire (Mandon, 1953).



**Figure 1:** Mâle adulte zébu Goudali, type Ngaoundéré pie rouge.



**Figure 2 :** Femelle adulte Goudali, type Ngaoundéré pie rouge.

*Pesée et mensurations corporelles effectuées sur les animaux*

L'échantillon d'étude était constitué de 340 zébus Goudali de Ngaoundéré. Ces animaux ont été bien identifiés comme appartenant à cette race Goudali et maintenus en permanence en stations de recherche et d'élevage. Sur chaque animal, les informations suivantes ont été relevées: la marque indélébile ou le numéro d'identification individuel visible sur la cuisse droite de l'animal, le sexe, l'âge déterminé à partir des numéros d'identification individuels répertoriés avec les dates de naissance dans un registre tenu par les stations.

Dans la présente étude, les animaux ont été répartis en catégories suivantes: veaux et velles sevrés et à la mamelle (jeunes âgés de moins de 12 mois); taurillons et génisses (jeunes âgés de 12 à 36 mois); ta*urea*ux et vaches suitées (adultes en reproduction et âgés de plus de 36 mois). Les vaches gestantes ont été exclues de l'échantillon.

La pesée a été réalisée sur les animaux à jeun à l'aide d'une bascule-pèse-bétail de portée maximale de 1500 kg et d'une sensibilité de 1 kg. Dix mensurations corporelles (Figure 3) ont été effectuées selon la technique décrite par Dodo *et al*. (2001) et Pagot et Delaine. (1959). Ces mensurations ont été également relevées sur les animaux à jeun maintenus dans un parc couloir de contention. Selon le type de mesure effectuée, les instruments suivants ont été utilisés: deux décamètres, deux rubans métriques de 3 mètres et une toise graduée en centimètres. Ces instruments de mesure ont une sensibilité d'un centimètre chacun. La bosse, très développé chez le zébu Goudali, a fait également objet de mesure au niveau de sa circonférence.

*Note d'état corporel*

L'observation des points anatomiques permet d'attribuer une note d'état corporelle (NEC) à l'animal (Vall et Bayala, 2004). Les points anatomiques observés ont été les suivants: la croupe, le détroit caudal, le ligament sacro-tubéral, les pointes de la fesse, la musculature de la cuisse, les apophyses transverses, les apophyses épineuses, les pointes de la hanches, les côtes, le creux de la hanche. L'appréciation du recouvrement de ces points anatomiques renseigne sur l'état de réserve corporelle à savoir le gras de couverture et la masse musculaire chez le bovin. L'échelle de 0 à 5 traduit l'état général des bovins (Vall et Bayala, 2004).

*Choix des formules barymétriques*

Toutes les informations relevées sur les animaux de l'échantillon ont été saisies dans le logiciel Microsoft Excel (Microsoft Office 2010) puis transférées vers le logiciel STATA 8 (stata corporation, College Station, Texas, USA) pour l'analyse statistique et la détermination des formules barymétriques en utilisant le modèle de régression linéaire. Le poids estimé a été considéré comme la variable dépendante (Y). Les variables indépendantes (X) ont été les dix mensurations corporelles effectuées sur les animaux. Les équations déterminées ont été comparées entre elles sur la base de leur coefficient de détermination (r2). Le coefficient de détermination est un indicateur statistique qui explique la relation entre deux variables. Plus il est proche de 1, plus le modèle de régression linéaire a une bonne prédictibilité pour estimer la valeur de la variable dépendante en fonction de la variable indépendante.

Plusieurs types de relation entre le poids (Y) et les mensurations effectuées (X) sont répertoriées dans la littérature (Chollou *et al*., 1978 ; Poivey *et al*., 1980 ; Bulgen *et al*., 1984; Dineur et Thys, 1986 ; Symoens et Hounsou, 1991 Dodo *et al*., 2001 ; Touré *et al*., 2017). Les régressions étudiées dans le cadre de cette étude ont été les suivantes: La régression linéaire simple, la régression polynomiale avec une variable, régression polynomiale utilisant deux variables et la régression exponentielle ou curvilinéaire.

Régression linéaire simple:

$$Y = AX + B$$

Régression polynomiale avec deux variables associées :

$$Y = AX1+BX2+C$$

Régression polynomiale du second et troisième degré avec une variable indépendante:

$$Y = AX2+BX+C ;$$
$$Y = AX3+BX2+CX+ D.$$
$$Y = AX2+ B ;$$
$$Y= AX3+B.$$

Régression puissance simple ou exponentielle:

$$Y= AXB .$$

La transformation logarithmique de la régression exponentielle donne la régression linéaire simple suivante:

$$lnY = lnA + BlnX.$$

La régression exponentielle fait partie de la famille des équations curvilinéaires. Elle est également appelée équation allométrique en raison de l'égalité des croissances différentielles des diverses parties du corps au cours du développement du l'organisme de l'animal (Huxley, 1932). Cette régression a été établie dans cette étude après transformations logarithmiques de toutes les données de mensurations et de pesée effectuées sur tous les animaux de l'échantillon.

*Estimation des erreurs du poids prédit par rapport au poids obtenu par pesée*

Dans chacun des groupes d'âges et de sexe (veaux, velles, taurillons, génisses, t*aurea*ux, vaches), 4 sujets ont été choisis au hasard dans un troupeau de bovins Goudali de Ngaoundéré (24 bovins Goudali) dans l'arrondissement de Vina (berceau de la race Goudali de Ngaoundéré). Des pesées ont été effectuées pour noter un poids observé (P) chez chaque animal. Le périmètre thoracique a été également mesuré chez chaque animal pour calculer un poids (P') à partir de la formule barymétrique retenue. La moyenne des erreurs entre le poids obtenu par pesée et le poids prédit par la formule barymétrique a été exprimé en pourcentage du poids obtenu par pesée: Erreur =[(P-P')/P]*100 (Dodo *et al*., 2001).

## Résultats

*Comparaison des équations de régression obtenues*

Le tableau 1 donne la composition de l'échantillon de bovins Goudali de Ngaoundéré, et le poids obtenu par pesée et les 10 mesures relevées sur les animaux. Plusieurs types de liaisons entre le poids et le les 10 mensurations on été comparées. Au total 630 équations de régressions différentes ont été formulées pour l'estimation du poids. Seules les équations de régressions ayant montré une forte corrélation entre le poids et la mensuration correspondante ont été reprises dans le tableau 2. La régression linéaire polynomiale utilisant la hauteur au garrot a montré une meilleure estimation du poids chez les veaux (r2=0,9382). Chez les velles, la régression polynomiale utilisant le périmètre thoracique est plus prédictive du poids (r2=0,9089). Le périmètre thoracique présente la meilleure prédictibilité pour estimer le poids vif chez les taurillons et les génisses. Les meilleures équations barymétriques sont de forme exponentielle tant chez les taurillons ($r^2$ = 0,9440) que chez les génisses ($r^2$ = 0,9224). Chez les t*aurea*ux et vaches (animaux adultes), la meilleure équation barymétrique est établie à partir de la régression exponentielle. La mensuration présentant la meilleure prédictibilité pour l'estimation du poids vif est le périmètre thoracique chez les t*aurea*ux ($r^2$ = 0,9295) et chez les vaches ($r^2$ = 0,8311). Chez les mâles et les femelles sans distinction de l'âge, le périmètre thoracique a la meilleure prédictibilité du poids vif avec la régression exponentielle (coefficient de détermination de 0,9751 pour les mâles et 0,9672 pour les femelles). La recherche d'équation unique de prédiction élargie à toutes les catégories d'âge et de sexe a révélé que la régression exponentielle permet de déterminer le poids avec une meilleure précision à partir du périmètre thoracique chez tous animaux (Y = 0,000160041X2,8467, r2 = 0,9701). Cette

**Tableau I :** Mensurations et poids relevés chez les Goudali de Ngaoundéré

| Groupe d'âge | Effectifs | HP (cm) | LA (cm) | LSI (cm) | CB (cm) | PT (cm) | LF (cm) | HG (cm) | HD (cm) | HH (cm) | HS (cm) | POIDS (kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Veaux | 34 | 51,29 | 113,82 | 89,88 | 52,21 | 109,35 | 34,32 | 96,74 | 93,29 | 96,24 | 97,62 | 106,21 |
| | | ± 6,42 | ± 16,87 | ± 13,94 | ± 9,48 | ± 17,07 | ± 5,50 | ± 11,76 | ± 11,32 | ± 11,78 | ± 11,89 | ± 45,35 |
| Velles | 26 | 51,15 | 109,54 | 87,23 | 47,27 | 106,35 | 34,08 | 97,08 | 93,15 | 96,50 | 97,85 | 98,54 |
| | | ± 6,45 | ± 15,12 | ± 13,07 | ± 8,65 | ± 14,71 | ± 5,23 | ± 11,10 | ± 10,98 | ± 11,36 | ± 11,53 | ± 36,79 |
| Taurillons | 58 | 65,48 | 151,19 | 123,91 | 80,07 | 153,29 | 47,28 | 121,03 | 116,86 | 120,69 | 122,52 | 280,00 |
| | | ±4,34 | ±14,17 | ±11,76 | ±17,00 | ±15,95 | ±3,99 | ±7,22 | ±7,21 | ±7,31 | ±7,47 | ±79,83 |
| Génisses | 65 | 64,95 | 147,58 | 123,22 | 66,72 | 153,34 | 46,68 | 120,43 | 116,40 | 120,00 | 122,02 | 265,15 |
| | | ± 5,28 | ± 14,23 | ± 12,54 | ± 11,64 | ± 15,22 | ± 4,11 | ± 6,78 | ± 6,62 | ± 7,00 | ± 7,26 | ± 71,78 |
| Ta*ureaux* | 60 | 70,92 | 173,05 | 138,92 | 100,40 | 175,18 | 50,93 | 129,65 | 125,27 | 129,28 | 131,10 | 416,12 |
| | | ±4,98 | ±13,10 | ±12,35 | ±20,65 | ±14,48 | ±2,72 | ±8,09 | ±7,92 | ±8,64 | ±8,81 | ±95,64 |
| Vaches | 97 | 68,80 | 163,71 | 135,67 | 77,71 | 169,14 | 50,12 | 128,16 | 123,95 | 127,44 | 129,33 | 351,92 |
| | | ± 3,66 | ± 10,83 | ± 9,05 | ± 10,67 | ± 9,79 | ± 1,79 | ± 5,24 | ± 5,19 | ± 5,57 | ± 5,61 | ± 52,85 |
| Tous les animaux | 340 | 64,77 | 151,01 | 123,57 | 75,14 | 153,70 | 46,31 | 120,21 | 116,11 | 119,71 | 121,50 | 290,44 |
| | | ± 8,23 | ± 24,22 | ± 20,84 | ± 21,02 | ± 26,75 | ± 6,87 | ± 13,79 | ± 13,52 | ± 13,93 | ± 14,16 | ± 122,51 |

*HP=hauteur de poitrine LA=longueur occipito-ischiale LSI=longueur scapulo-ischiale*
*CB=circonférence de bosse PT=périmètre thoracique*
*LF=longueur du front HG=hauteur au garrot HD=hauteur au dos HH=hauteur à la hanche HS=hauteur au sacrum*

**Tableau 2:** Récapitulatif de meilleures des équations de régression chez le Goudali de Ngaoundéré

| Catégories d'âge et de sexe | Meilleures équations de régression | Coefficient de détermination (r2) |
|---|---|---|
| Veaux | Y=0,000662094HG3-0,119647HG2+ 8,19815HG-176,015 | 0,9382 |
| Velles | Y=0,00104724PT3+0,31693PT2+ 33,5746PT-1151,23 | 0,9089 |
| Taurillons | $Y=0,00033703PT^{2,70305}$ | 0,9440 |
| Génisses | $Y=0,000256765PT^{2,74629}$ | 0,9224 |
| Tau*rea*ux | $Y=0,0000404PT^{3,12122}$ | 0,9295 |
| Vaches | $Y=0,000275236PT^{2,73862}$ | 0,8311 |
| Mâles | $Y=0,000124494PT^{2,90124}$ | 0,9751 |
| Femelles | $Y=0,000201305PT^{2,79759}$ | 0,9672 |
| Tous les sujets | $Y=0,000160041PT^{2,8467}$ | 0,9701 |

*HG : Hauteur au garrot*

**Tableau 3:** Table de conversion du périmètre thoracique (PT) en poids

| PT (cm) | POIDS (kg) | PT (cm) | POIDS (kg) | PT (cm) | POIDS (kg) | PT (cm) | POIDS (kg) |
|---|---|---|---|---|---|---|---|
| 70 | 29 | 106 | 93 | 142 | 214 | 178 | 408 |
| 71 | 30 | 107 | 96 | 143 | 219 | 179 | 414 |
| 72 | 31 | 108 | 98 | 144 | 223 | 180 | 421 |
| 73 | 32 | 109 | 101 | 145 | 228 | 181 | 428 |
| 74 | 34 | 110 | 104 | 146 | 232 | 182 | 434 |
| 75 | 35 | 111 | 106 | 147 | 237 | 183 | 441 |
| 76 | 36 | 112 | 109 | 148 | 241 | 184 | 448 |
| 77 | 38 | 113 | 112 | 149 | 246 | 185 | 455 |
| 78 | 39 | 114 | 115 | 150 | 251 | 186 | 462 |
| 79 | 40 | 115 | 118 | 151 | 255 | 187 | 469 |
| 80 | 42 | 116 | 121 | 152 | 260 | 188 | 477 |
| 81 | 43 | 117 | 124 | 153 | 265 | 189 | 484 |
| 82 | 45 | 118 | 127 | 154 | 270 | 190 | 491 |
| 83 | 46 | 119 | 130 | 155 | 275 | 191 | 498 |
| 84 | 48 | 120 | 133 | 156 | 280 | 192 | 506 |
| 85 | 50 | 121 | 136 | 157 | 285 | 193 | 513 |
| 86 | 51 | 122 | 139 | 158 | 291 | 194 | 521 |
| 87 | 53 | 123 | 142 | 159 | 296 | 195 | 529 |
| 88 | 55 | 124 | 146 | 160 | 301 | 196 | 537 |
| 89 | 57 | 125 | 149 | 161 | 306 | 197 | 544 |
| 90 | 59 | 126 | 153 | 162 | 312 | 198 | 552 |
| 91 | 60 | 127 | 156 | 163 | 317 | 199 | 560 |
| 92 | 62 | 128 | 160 | 164 | 323 | 200 | 568 |

| PT (cm) | POIDS (kg) | PT (cm) | POIDS (kg) | PT (cm) | POIDS (kg) | PT (cm) | POIDS (kg) |
|---|---|---|---|---|---|---|---|
| 93 | 64 | 129 | 163 | 165 | 329 | 201 | 576 |
| 94 | 66 | 130 | 167 | 166 | 334 | 202 | 585 |
| 95 | 68 | 131 | 170 | 167 | 340 | 203 | 593 |
| 96 | 70 | 132 | 174 | 168 | 346 | 204 | 601 |
| 97 | 72 | 133 | 178 | 169 | 352 | 205 | 610 |
| 98 | 75 | 134 | 182 | 170 | 358 | 206 | 618 |
| 99 | 77 | 135 | 186 | 171 | 364 | 207 | 627 |
| 100 | 79 | 136 | 190 | 172 | 370 | 208 | 635 |
| 101 | 81 | 137 | 194 | 173 | 376 | 209 | 644 |
| 102 | 84 | 138 | 198 | 174 | 382 | 210 | 653 |
| 103 | 86 | 139 | 202 | 175 | 389 | 211 | 662 |
| 104 | 88 | 140 | 206 | 176 | 395 | 212 | 671 |
| 105 | 91 | 141 | 210 | 177 | 401 | 213 | 680 |

équation curvilinéaire a été retenue comme meilleure formule pouvant estimer le poids du Goudali de Ngaoundéré. Cette formule barymétrique retenue a été utilisée pour la réalisation de la courbe d'évolution du poids en fonction du périmètre thoracique (Figure 4) et l'établissement d'une table de conversion du périmètre thoracique en poids (Tableau 3).

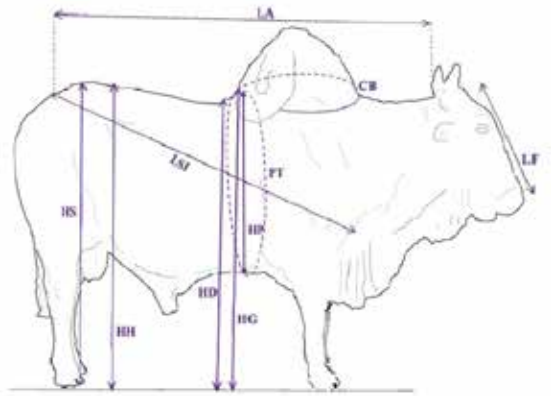
*La circonférence de la bosse et l'état corporel des animaux étudiés*

Les animaux ayant une bosse tombante (du côté droite de l'animal) représentent 61% de l'échantillon. Le poids a été fortement corrélé à la circonférence de bosse (r = 0,85). Aucune différence significative n'a été observée entre la moyenne des poids des animaux ayant la bosse inclinée à gauche et celle des animaux ayant la bosse inclinée à droite (P> 0.05). Chez les mâles la moyenne des circonférences de la bosse est plus élevée que celle enregistrée chez les femelles.

La moyenne des notes d'état corporelle (NEC) des animaux a été de 3,3. Considérée par catégories d'animaux, la NEC influence le périmètre thoracique chez les mâles et les femelles adultes (une valeur élevée de périmètre thoracique est observée chez les animaux adultes ayant une NEC supérieure à la moyenne).

*Estimation des erreurs du poids prédit par rapport au poids obtenu par pesée*

Le périmètre thoracique a été mesuré chez tous les animaux de l'échantillon dont le poids individuel (P) est connu par pesée. Le poids prédit (P') a été calculé à partir de la formule barymétrique retenue. Les valeurs de P et P' et les erreurs sur le poids prédit figurent dans les Tableau 4. Il n'y a pas de différence significative entre la moyenne de P et P' (P>0,05). Il n'y a pas eu une sous-estimation ou surestimation du poids prédit. L'erreur du poids prédit a été inférieure à 6,4 % (95% IC : 4,25%- 8,58 %) du poids obtenu par pesée.




*HP=hauteur de poitrine LA=longueur occipito-ischiale ; LSI=longueur ; scapulo-ischiale; CB=circonférence de bosse ; PT=périmètre thoracique LF=longueur du front ; HG=hauteur au garrot ; HD=hauteur au dos ; HH=hauteur à la hanche ; HS=hauteur au sacrum.*

**Figure 3:** Mensurations effectuées sur un mâle Goudali de Ngaoundéré

**Tableau 4:** Estimation des erreurs du poids prédit par rapport au poids obtenu par pesée

| Groupe d'âge et de sexe | Périmètre thoracique (cm) | POIDS (kg) par pesée (P) | POIDS (kg) par calcul (P') | Erreur en % [( /P)x100] |
|---|---|---|---|---|
| veau | 87 | 58 | 53 | 9 |
| veau | 105 | 85 | 91 | 7 |
| veau | 115 | 124 | 118 | 5 |
| veau | 112 | 117 | 109 | 7 |
| velle | 82 | 42 | 45 | 7 |
| velle | 113 | 100 | 112 | 12 |
| velle | 128 | 150 | 160 | 7 |
| velle | 131 | 162 | 170 | 5 |
| taurillon | 149 | 254 | 246 | 3 |
| taurillon | 153 | 255 | 265 | 4 |
| taurillon | 159 | 323 | 296 | 8 |
| taurillon | 170 | 352 | 358 | 2 |
| génisse | 120 | 151 | 133 | 12 |
| génisse | 145 | 253 | 228 | 10 |
| génisse | 155 | 262 | 275 | 5 |
| génisse | 167 | 357 | 340 | 5 |
| t*aurea*u | 159 | 316 | 296 | 6 |
| t*aurea*u | 166 | 366 | 334 | 9 |
| t*aurea*u | 166 | 340 | 334 | 2 |
| t*aurea*u | 168 | 368 | 346 | 6 |
| vache | 155 | 300 | 275 | 8 |
| vache | 160 | 281 | 301 | 7 |
| vache | 172 | 382 | 370 | 3 |
| vache | 172 | 388 | 370 | 5 |

## Discussion

Les dix mensurations relevées sont fortement corrélées au poids chez les Goudali de Ngaoundéré. Ceci confirme les observations décrites par Crimella *et al*. (2003) qui ont mis en évidence l'existence d'un lien entre le poids vif et des mensurations corporelles chez des zébus Goudali du Cameroun. A notre connaissance, la forte corrélation de la circonférence de la bosse au poids est relevée ici pour la première fois chez un zébu Africain. La mensuration ayant apporté le plus de précision sur la valeur prédictive du poids vif chez toutes les catégories d'âge et de sexe a été le périmètre thoracique (r2=0,9701). La meilleure prédictibilité du périmètre thoracique pour estimer le poids vif des bovins Africains a été également rapportée par plusieurs auteurs chez le zébu Gobra au Sénégal (Chollou *et al*., 1978), les zébus Azawak du Mali (Touré *et al*., 2017), les taurins Kapsiki au Cameroun Dineur, et Thys, 1998), les taurins Ndama au Congo Brazzaville (Akouango et Mopoundza, 2014), les taurins Borgou au Bénin (Symoens et Hounsou, 1991). Par contre, chez les zébus Azawak du Niger, le périmètre thoracique est associé à la longueur scapulo-ischiale pour plus de précision de la formule barymétrique (Dodo *et al*, 2001). Toutefois, Planchenault et Boutonnet, (1997) recommandent l'utilisation du périmètre thoracique comme mensuration

unique pour estimer le poids vif et permettre de concevoir un ruban barymètrique et une table de conversion pour une lecture directe du poids. Si l'utilisation du périmètre thoracique vise à déterminer une formule barymètrique chez une race de bovin (bovin Gobra, Azawak, Borgou, Kapsiki, par exemple.) dans les études menées en Afrique, l'exception peut être relevée dans l'étude de Njoya *et al.* (1997) qui ont utilisé cette méthode sur un échantillon constitué de populations *bovine*s hétérogènes du Nord-Cameroun (39 % zébus Akou, 28 % Goudali, 18 % autres type Mbororo et 15 % Arabe Choa et types Sahéliens du Nord-Cameroun). Deux équations linéaires polynomiales distinctes pour chaque catégorie de sexe (mâle et femelle) ont été déterminées par ces auteurs. Ces formules d'ajustement linéaire obtenues par ces auteurs ne peuvent pas être précises, vue l'hétérogénéité de l'échantillon. Dans une étude de recherche des formules biométriques de prédiction de poids chez les races *bovine*s exploitées en France, Vissac et Le Rouilly (1966) ont démontré que la précision des équations de régression identifiées dépend de l'homogénéité de la race *bovine* considérée. En tenant compte uniquement du périmètre thoracique, la régression curvilinéaire est plus prédictive du poids vif chez les zébus Goudali de Ngaoundéré comparée aux équations de régression polynomiale obtenues par Njoya *et al.* (1997) sur une population *bovine* composée de différents types de bovins du Nord-Cameroun. La meilleure précision de la régression curvilinéaire obtenue chez les zébus Goudali Ngaoundéré serait aussi liée à leur conformation bouchère (Mandon, A. 1953) traduite par une formule d'équation allométrique curvilinéaire exprimant mieux la relation entre la masse et le volume de l'animal (Huxley, 1932; Vissac et Le Rouilly, 1966).

La moyenne des erreurs entre le poids obtenu par pesée et le poids prédit par l'équation barymétrique exprimée en pourcentage du poids obtenu par pesée a été inférieure à 6,4 % (95% IC : 4,25%- 8,58 %) chez les Goudali de Ngaoundéré. Ces erreurs sont comparables à celles observées par Dodo *et al.* (2001) et inférieures à celles rapportées par Buldgen *et al.* (1984). Toutefois une réduction de l'erreur (inférieure à 5 %) est observée chez les adultes Goudali (mâles et femelles). Cette réduction de l'erreur semble liée à la NEC qui influence la valeur du périmètre thoracique chez les adultes. Des observations similaires ont été faites sur les zébus Boran d'Ethiopie (Nicholson et Sayers, 1987) qui sont très proches du Goudali de Ngaoundéré (les deux types de bovins étant des zébus Africains à courtes cornes).

## Conclusion

La meilleure formule barymétrique pour estimer le poids chez le zébu Peul Goudali de Ngaoundéré est la régression curvilinéaire classique basée sur le périmètre thoracique contrairement à la régression polynomiale déterminée par Njoya *et al.* (1997) sur une population hétérogène des bovins du Nord-Cameroun. La mesure du périmètre thoracique peut être utilisée seule dans la formule barymétrique chez le zébu Goudali sans faire recours à une deuxième mensuration pour augmenter la précision de la formule. L'erreur absolue (différence entre le poids obtenu par la pesée et le poids prédit par la formule barymétrique) étant faible chez les adultes Goudali de Ngaoundéré, cette équation curvilinéaire retenue est mieux indiquée pour déterminer le poids chez cette catégorie d'âge. Cette étude est d'un intérêt essentiel pour l'appréciation des performances pondérales du zébu Goudali de Ngaoundéré en divers lieux de son exploitation. Un ruban barymétrique confectionné à partir de ces données constituerait un outil pratique destiné aux acteurs intervenant dans la filière de production de cette race *bovine* considérée comme le meilleur type de bétail de boucherie que possède le Cameroun.

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# EFFECT OF BREAD WASTE AND *MORINGA OLEIFERA* LEAVES (BWMO) IN THE BASAL DIET OF RABBITS

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## Abstract

Sixty mixed breeds of rabbits were allotted into four treatments in a completely randomized design along eight weeks in order to evaluate effect of bread waste and Moringa oleifera leaf (BWMO) when added to the diet. Treatment (BWMO) at different levels (BWMO -0, BWMO -25, BWMO -50 and BWMO -100%) was added to mashed diet. Chemical composition of the diet was determined as well as average daily gain of animals, digestibility, blood components and carcass quality. Chemical composition of bread waste consists of 85.0% DM, 11.0% CP, 0.10% CF, 19.4% EE, 1.60% Ash, and 54.0%NFE. The CP of diets containing BWMO was higher ($p<0.05$) than BWMO-0. The weight gain of the rabbits fed diet BWMO-100 (17.6g/day) was highest ($p<0.05$) compared to BWMO-50 (16.6g/day), BWMO-25 (12.1g/day) and BWMO-0 (10.8g/day). As BWMO level increased in the diet, the digestible energy and protein of diets BWMO-100, BWMO-50 and BWMO-25 were higher ($p<0.05$) than BWMO-0. The blood cholesterol content of rabbits fed BWMO-0 (41.6) was higher ($p<0.05$) than diets BWMO-25 (33.8), BWMO-50 (37.5) and BWMO-100 (35.9). The total protein and albumin was higher ($p<0.05$) in rabbits fed diet containing BWMO. The loin, hind limb and fore limb weight of rabbits fed diet BWMO-100 were higher ($p<0.05$) than those fed other diets. It could be concluded that BWMO had positive effect on the performances of rabbits.

**Keywords:** Utilization, bread waste, Moringa oleifera, rabbits

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## Introduction

Rabbit production is one way of meeting the animal protein requirement of the Nigeria populace (Iyeghe-Erakpotobor *et al*., 2012). Rabbits are characterised by their high prolificacy, a good mothering ability, an easy management strategy, the ability to valorise waste and other unconventional feed sources for maximum meat gain (Bassey *et al*., 2008) including the ability to thrive well on forage (Fielding, 1991) with little concentrate. Moreover, rabbit meat is known to contain high quality and quantity of protein, less fat with higher proportion of polyunsaturated linoleic and linolenic fatty acids (Njidda and Isidahomen, 2011). Based on these attributes recorded to rabbit over other livestock, researchers have focused more interest to improve performance by feeding rabbit with agro-industrial wastes and forages, cheap and available resources throughout the year. The most common unconventional feedstuffs (agro-industrial wastes) are cassava peel, brewer's dried grain, pineapple waste, flour dust, biscuit waste, bread waste, noodle waste, cocoa pod meal and shrimp waste. Bread waste, a by-product obtained from bakery industry, is rich in vitamin and energy but low in fibre content (Al-Tulaihan *et al*., 2004). In Nigeria, Moringa oleifera, commonly called horse radish tree, is an inexpensive forage protein source for livestock feeding (Odeyinka *et al*., 2008). At our best knowledge there is no studies reported on the utilization of bread waste and Moringa oleifera leaves as supplemental feed source in the diet of rabbit especially during the dry season when native forages are scarce. Therefore, this study was carried out to evaluate the performance, blood components and carcass qualities of rabbits fed on a mixture of bread waste and Moringa oleifera leaves (BWMO) when added, at different levels, to basal diet.

## Materials and Methods

*Animals and experimental design*

Sixty weaned rabbits of mixed breeds aged between 5 and 6 weeks were used among the adaptation (7-days) and studied period (8 weeks). The rabbits were housed in individual hutches and randomly allocated into four treatment groups (15 rabbits per treatment). Feed and water were daily served ad libitum.

*Experimental diets*

Bread wastes were collected from bakery, oven dried at 60°C for 24 hours, packaged in high-density polythene bags and stored for subsequent use.Fresh Moringa oleifera leaves were harvested from Obafemi Awolowo University Teaching and Research farm, Ile-Ife, Nigeria and air dried on a concrete floor for 4 days. Four were compounded with inclusion of bread waste and Moringa oleifera leaves (BWMO) at 0, 25, 50 and 100% levels (BWMO- 0, BWMO-25, BWMO-50 and BWMO-100) as shown in Table 1. The experimental diets were fed to rabbits at 4% of their body weight.

*Digestibility study*

Animals were subjected to a 7-day digestion trial. The total excreted faeces were collected daily, oven dried, bulked, thoroughly mixed and ground through a 2mm hammer screen for chemical analysis. The digestibility values for dry matter (DM), crude protein (CP), ether extract (EE), and crude fibre (CF) were calculated as nutrient intake minus nutrient excreted divided by nutrient intake multiplied by hundred. Urine samples collected were stored in refrigerator at 4oC for chemical analysis.The crude protein content of experimental diets was divided by a factor of 6.25 to calculate the nitrogen intake of rabbits. The faecal and urinary nitrogen contents were determined using the method described by AOAC (2000)

*Chemical analysis*

Ash, crude protein (CP) and ether extract (EE) and crude fibre (CF) were determined following the methods of the AOAC (2000)

*Blood sample collection and analysis*

At the end of the feeding period, animals were starved of feed for 24 hours before collecting blood samples. Samples were collected per replicate from each rabbit from the external ear vein using a sterilized disposable syringe and needle between 6.30 and 7.30 am for haematological and biochemical analysis. An initial 1.0 ml blood was collected into labelled sterile universal bottles containing Ethylene- Diamine-Tetra-Acetic acid (EDTA) as anticoagulant. Another 1.0 ml of blood was collected into labelled sterile bottles without anticoagulant in order to determine the biochemical components. Albumin concentration was determined by the Bromocresol Green (BCG) method (Peters *et al*., 1982). Globulin (Gb) concentration was computed as the difference between total protein and albumin concentrations. Cholesterol was determined as described by Coles (1986). The red blood cell (RBC) counts, total white blood cell (WBC) counts, haemoglobin (Hb) concentration and packed cell volume (PCV) parameters were determined following standard procedures described by Device and Lewis (1991).

*Determination of animal performance and carcass quality*

Animals were weighed before the commencement of the experiment and subsequently weekly throughout the experimental period wherein the initial weight, final weight and average daily weight gains were calculated.

At the end of the experimental period, eight rabbits per treatment were randomly selected, starved of feed for 24 hours, weighed and slaughtered by cutting the jugular vein to allow proper bleeding. Thereafter, skin, head, loin, fore limb, hind limb, kidney, kidney fat, intestine, liver, lungs and heart were removed and weighed (Odeyinka *et al*., 20087).

*Data analysis*

Statistical differences among experimental diets in all studied parameters were evaluated by one-way analysis of variance (SAS, 2008). The statistical significance of the differences between means was assessed using the Duncan test

## Results

The percentage chemical composition of bread waste and experimental diets are presented in Table 2. Dry matter contents (DM) varied between 85% (bread waste) and 96 % (BWMO-0). The CP content of BWMO diets increased with increasing inclusion levels but with much lower EE content compared to bread waste. Data on some performance characteristics are presented in Table 3. There was no significant difference ($p>0.05$) in the mean daily feed intake of the rabbits fed the experimental diets. Rabbits fed diets BWMO-50 and BWMO-100 had significantly higher ($p<0.05$) daily weight gain compared to BWMO-25 and BWMO-0. There was significance difference ($P<0.05$) in the feed conversion ration throughout the experimental diets.

There was significant difference ($P<0.05$) among the means of the percentage digestibility coefficient of the rabbits fed bread waste and Moringa oleifera meal (Table 4). The percentage dry matter digestibility decreases as the inclusion of BWMO increases in the diets. The digestible energy and crude protien of diets BWMO-100, BWMO-50 and BWMO-25 were significantly higher ($p<0.05$) than that of BWMO. There was no significant difference ($p>0.05$) in the digestible ether extract among the experimental diets. The BWMO-0 diet had significantly highest ($p<0.05$) digestible ash followed by BMWO-25, BWMO-50 and BWMO-100. There was significant difference ($p<0.05$) among the means of nitrogen utilization of rabbits fed the experimental diets (Table 5). The nitrogen intake of diets BWMO-0 and BWMO-25 were significantly lower ($p<0.05$) than that of diets BWMO100 and BWMO-50. The nitrogen retention percentage was significantly higher ($p<0.05$) in diets BWMO-100, BWMO-50, BWMO-25 than BWMO-0.

**Table 1:** Gross composition of the experimental diets

| Ingredient (%) | BWMO-0 | BWMO-25 | BWMO-50 | BWMO-100 |
|---|---|---|---|---|
| Corn bran | 40.00 | 30.00 | 20.00 | - |
| Brewer's dried grain | 40.00 | 30.00 | 20.00 | - |
| Bread waste | - | 10.00 | 20.00 | 40.00 |
| *Moringa oleifera* | - | 10.00 | 20.00 | 40.00 |
| Groundnut cake | 17.00 | 17.00 | 17.00 | 17.00 |
| Bone meal | 2.00 | 2.00 | 2.00 | 2.00 |
| Methionine | 0.25 | 0.25 | 0.25 | 0.25 |
| Lysine | 0.25 | 0.25 | 0.25 | 0.25 |
| Vitamin premix | 0.50 | 0.50 | 0.50 | 0.50 |

*[1]Premix provided per kg diet: vitamin A, 12,000 IU; vitamin D3, 1,000 IU; vitamin E acetate, 50 mg; vitamin K3, 2 mg; biotin, 0.1 mg; Fe, 100 mg; Cu, 20 mg; Mn, 50 mg; Co, 2 mg; I, 1 mg; Zn, 100 mg; Se, 0.1 mg; Robenidine, 66 mg.*

**Table 2:** Percentage chemical composition of bread waste and experimental diets

| Parameters (%) | Bread waste | BWMO-0 | BWMO-25 | BWMO-50 | BWMO-100 |
|---|---|---|---|---|---|
| Dry matter | 85.00 | 96.00 | 92.00 | 86.00 | 88.00 |
| Crude protein | 11.00 | 15.20 | 17.50 | 19.00 | 19.20 |
| Crude fibre | 10.10 | 17.00 | 16.00 | 12.00 | 11.00 |
| Ether extract | 19.40 | 5.50 | 6.50 | 6.90 | 6.80 |
| Ash | 1.60 | 10.00 | 9.20 | 8.50 | 7.50 |
| NFE | 54.00 | 38.50 | 37.70 | 37.20 | 36.20 |

*NFE: nitrogen free extract.*

**Table 3:** Performance characteristics of rabbits supplemented with bread waste and *Moringa oleifera* leaves

| Parameters | BWMO-0 | BWMO-25 | BWMO-50 | BWMO-100 | SEM | Prob. |
|---|---|---|---|---|---|---|
| Feed intake (g/day) | 43.10 | 45.30 | 43.60 | 46.40 | 0.62 | <0.0001 |
| Initial weight (g) | 53.50 | 54.00 | 53.40 | 54.10 | 0.19 | <0.0001 |
| Final weight (g) | $118^{d}$ | $126^{c}$ | $153^{b}$ | $160^{a}$ | 5.33 | <0.0001 |
| Weight gain (g/day) | $10.80^{d}$ | $12.10^{c}$ | $16.60^{b}$ | $17.60^{a}$ | 0.88 | <0.0001 |
| Feed conversion ratio | $3.87^{a}$ | $3.74^{a}$ | $2.56^{b}$ | $2.63^{b}$ | 0.18 | <0.0001 |

*$^{abc}$ Means with different letters on the same row differ (P<0.01)*

There were no significant differences (p>0.05) among the means of the packed cell volume and the white blood cell counts of the animals while the red blood cell counts was significantly higher (P<0.05) in diets containing inclusion of BWMO. Furthermore, the serum metabolites were also significantly higher (P<0.05) in diets containing BWMO levels than the diet with BWMO-0.The blood cholesterol content of rabbits fed diets BWMO-0 had significantly higher (P<0.05) than diets BWMO-25, BWMO-50 and BWMO-100. There was no significant difference (p>0.05) among the means of the slaughter weight of the rabbits fed experimental diets (Table 7). There was significant difference (p<0.05) among the means of the carcass weight with BWMO-100 being significantly highest followed by BWMO-50, BWMO-25 then BWMO-0. The dressing percentage and loin weight of rabbis fed diets

BWMO-100, BWMO-50 and BWMO-25 were significantly higher ($p<0.05$) than rabbits fed BWMO-0 diet. Likewise, the hind and fore limb weight were significantly higher ($P<0.05$) in rabbits fed diets containing BWMO compared to the BWMO-0 diet. There was no significant difference ($p>0.05$) in the weight of all the visceral organs such as liver, kidney, heart, lungs and spleen across the treatments.

**Table 4:** Apparent digestibility (%) of the experimental diets.

| Parameters (%) | BWMO-0 | BWMO-25 | BWMO-50 | BWMO-100 | SEM | Prob. |
|---|---|---|---|---|---|---|
| DDM | 82.1$^{a}$ | 76.4$^{ab}$ | 77.4$^{b}$ | 71.1$^{b}$ | 1.84 | 0.04 |
| DE | 66.0$^{c}$ | 74.0$^{b}$ | 75.4$^{b}$ | 79.3$^{a}$ | 1.70 | 0.03 |
| DCP | 53.4$^{c}$ | 57.8$^{b}$ | 61.5$^{a}$ | 63.6$^{a}$ | 1.30 | 0.05 |
| DCF | 69.4$^{b}$ | 58.5$^{c}$ | 54.9$^{c}$ | 71.8$^{a}$ | 1.60 | 0.01 |
| DEE | 61.9 | 60.3 | 60.2 | 58.5 | 1.50 | 0.21 |
| DNFE | 41.0 | 39.5 | 37.8 | 38.1 | 0.92 | 0.50 |

$^{abc}$ *Means with different letters on the same row differ (P<0.05)*
*DDM: Digestible dry matter, DE: Digestible energy, DCP: Digestible crude protein, DCF: Digestible crude fibre, DEE: Digestible ether extract, DNFE: Digestible nitrogen free extract. .*

**Table 5:** Nitrogen utilization of bread waste and *Moringa oleifera* leaves supplemented to rabbit's feed

| Parameter | BWMO-0 | BWMO-25 | BWMO-50 | BWMO-100 | SEM | Prob. |
|---|---|---|---|---|---|---|
| Nitrogen Intake | 2.40$^{b}$ | 2.70$^{b}$ | 3.03$^{ab}$ | 3.10$^{a}$ | 0.37 | 0.03 |
| Feacal Nitrogen | 0.43$^{ab}$ | 0.39$^{b}$ | 0.54$^{a}$ | 0.50$^{ab}$ | 0.02 | 0.04 |
| Urinary Nitrogen | 0.65$^{a}$ | 0.47$^{b}$ | 0.38$^{c}$ | 0.33$^{d}$ | 0.05 | 0.02 |
| Nitrogen Balance | 1.42$^{c}$ | 1.85$^{c}$ | 2.12$^{b}$ | 2.43$^{a}$ | 0.11 | 0.03 |
| Nitrogen Retention (%) | 57.9$^{b}$ | 68.3$^{ab}$ | 69.9$^{ab}$ | 78.6$^{a}$ | 2.54 | 0.01 |

$^{abc}$ *Means with different letters on the same row differ (P<0.05)*

**Table 6:** The blood components of rabbit

| Parameter | BWMO-0 | BWMO-25 | BWMO-50 | BWMO-100 | SEM | Prob. |
|---|---|---|---|---|---|---|
| PCV (%) | 32.2 | 33.8 | 34.0 | 34.8 | 1.44 | 0.03 |
| RBC (106) | 2.84$^{a}$ | 4.98$^{a}$ | 5.00$^{a}$ | 4.93$^{a}$ | 0.39 | 0.04 |
| WBC (103) | 4.95 | 4.70 | 4.89 | 4.45 | 0.06 | 0.31 |
| Cholesterol (mg/dl) | 41.6$^{a}$ | 33.8$^{b}$ | 37.5$^{b}$ | 35.9$^{b}$ | 1.08 | 0.05 |
| Total protein (mg/dl) | 5.40$^{c}$ | 6.43$^{b}$ | 6.99$^{ab}$ | 7.70$^{a}$ | 0.33 | 0.03 |
| Albumin (mg/dl) | 3.30$^{b}$ | 3.98$^{ab}$ | 4.15$^{a}$ | 4.69$^{a}$ | 0.20 | 0.05 |
| Globulin (mg/dl) | 2.10$^{b}$ | 2.50$^{a}$ | 2.84$^{a}$ | 2.87$^{a}$ | 0.13 | 0.02 |

$^{abc}$ *Means with different letters on the same row differ (P<0.05)*
*PCV: Packed cell volume RBC: Red blood cell WBC: White blood cell*

**Table 7:** The carcass characteristics of rabbits

| Parameter | BWMO-0 | BWMO-25 | BWMO-50 | BWMO-100 | SEM | Prob. |
|---|---|---|---|---|---|---|
| Slaughter weight | 103 | 105 | 108 | 112 | 32.1 | 0.64 |
| Carcass weight | 816$^{b}$ | 883$^{ab}$ | 825$^{b}$ | 988$^{a}$ | 27.60 | 0.11 |
| Loin | 228$^{b}$ | 325$^{a}$ | 237$^{b}$ | 312$^{a}$ | 17.30 | 0.05 |
| Head | 100 | 115 | 113 | 125 | 6.210 | 0.73 |
| Fore limb | 25.0$^{b}$ | 32.5$^{ab}$ | 37.5$^{ab}$ | 55.0$^{a}$ | 4.53 | 0.07 |
| Hind limb | 50.5$^{c}$ | 52.0$^{c}$ | 75.0$^{b}$ | 100$^{a}$ | 7.64 | 0.04 |
| Liver | 38.1 | 40.9 | 39.8 | 41.8 | 4.36 | 0.32 |
| Kidney | 9.09 | 10.6 | 9.29 | 9.53 | 0.79 | 0.82 |
| Heart | 2.79 | 3.43 | 2.84 | 3.07 | 0.16 | 0.48 |
| Lungs | 4.92$^{b}$ | 5.37$^{b}$ | 6.81$^{a}$ | 6.73$^{a}$ | 0.43 | 0.38 |

$^{abc}$ *Means with different letters on the same row differ (P<0.05)*

## Discussion

The DM of bread waste in this study is lower than those reported by (Omole *et al*., 2011) who pointed out 98.8% DM. Likewise, CP contents varied between 11% (bread waste) and 19.2% (BWMO-100) higher than 11.96% reported by Malomo *et al*., (2011) on composite bread made from breadfruit flour, breadnut flour . Moreover, CP contents of the experimental diets (15.2-19.2%) are higher than those reported by Mmereole *et al*., (2011) who recorded levels between 12.1 and – 16.0%. Levels of CF revealed a linear decrease with increasing BWMO in the diet. Bread waste contained the lowest levels. Moreover values presented herein in experimental diets are fairly higher (11-17%) than those pointed out by Al-Shami and Mohammed (2009) for diets containing bread waste crumb (9.6 - 14.60%). It could therefore be inferred from this study that the inclusion of BWMO in the diet of rabbits provided the nutrients required for maintenance and production functions especially during the dry season.

The daily feed intake values are considered lower than those recorded by Federick (2010) for Moringa based diet (60.1-63.4 g/day); however similar results were reported earlier by Mufwa *et al*., (2011) for rabbits fed brewers dried grains. However, there were slight increases in numeric values of diet containing inclusion of BWMO than the other diet. This could be associated with increasing levels of protein in the BWMO diets. The daily weight gain range recorded in this study for diets containing BWMO was higher compared to 6.78 – 8.64 g/day (Odeyinka *et al*., 2008) for rabbits fed Moringa oleifera as replacement for centrosema pubescens. The higher weight gains in the rabbits fed the BWMO inclusive diets may, therefore, be partly due to a better protein quality, possibly arising from a higher methionine and lysine supply (Booth and Wickens, 1998). The values obtained in this study were lower than 5.11 – 7.66 reported by Mmereole *et al*., (2011) for rabbits fed protein diets supplemented with Tridax procumbens than 2.63- 4.00 reported by earlier researchers in the tropics (Okorie, 2003). This observation could be attributed to enhanced feed intake and better utilization of diets. Hence increase in weight gain of rabbits fed BWMO lead to improvement in the feed conversion ratio. The digestible dry matter was higher than 65.02 - 78.40% reported by Odeyinka *et al*., (2008) for rabbits fed Moringa diet. The apparent digestibility of CP was higher than 26.28 - 62.48% reported for rabbits in the tropics (Iyeghe-Erakpotobor *et al*., 2006). The fact that digestible crude protein contents and digestible energy increased as the level of bread waste and Moringa leaf increased in the diets here agreed with the study of Fahey *et al*.,(2001)

that Moringa is an outstanding source of highly digestible nutrients. All animals fed on any of the experimental diets had a positive nitrogen balance values. The nitrogen balance in this study were higher than 1.62 – 1.64 reported by Adeniji and Lawal (2012) for rabbits fed Moringa based diets. The percentage nitrogen retention values for animals fed diets containing bread waste and M. oleifera leaf were relatively similar to 70.31 – 70.56 reported (Adeniji and Lawal, 2012). The packed cell volume in this present study was lower than 43.30 – 46.77% (Federick, 2010) but conformed to (32.00 – 35.00 %) observed by Odetola *et al*., (2012) for rabbits fed Moringa oleifera leaves as replacement for soybean meal. The rabbits fed diets containing BWMO had higher red blood cell counts which affirmed the claim of Brown *et al*., (2000) who reported that increased red blood cell count values are associated with high quality dietary protein and with disease free animals. Also the white blood cell count conformed to 4.34 –5.88 x 103 observed by Dairo and Egbeyemi (2012) rabbits fed mixture of cassava peels and layer's manure. The blood cholesterol levels conformed to 35.02 – 40.70 mg/dl obtained by Federick (2010) for rabbits fed M. oleifera leaf and also fell within the normal physiological range of 35 – 60 mg/dl reported by Jenkins (1993). The blood cholesterol level reduced as the level of inclusion of BWMO increased in the experimental diets. This observation agrees with the results of a research by Ghasi *et al*., (1999) where they reported that juice extracted from Moringa leaves was found to be a potent hypocholesterolemic agent. The values for total protein, albumin and globulin obtained in this study are found to be within the normal physiological range for rabbits; total protein (5.4 – 7.5 g/dl), albumin (2.5 – 4.5 g/dl) and globulin (1.9 – 3.5 g/dl) (Hillyer, 1994). Hence, BWMO in the diet of rabbits had no adverse effect on the blood components. The carcass weight values here were comparable to 764.79 – 878.00 g reported by Ojebiyi *et al*., (2013) but higher than 354.31 – 738.40 g (Adekojo *et al*., 2014) for rabbits fed processed Leuceana luecocephala leaves. The loin and head weights in this study were higher than the values reported by Ngoshe *et al*., (2013). Generally, the carcass quality parameters of rabbits fed diets containing BWMO were superior compared to rabbits fed the other diet. This agreed with the observations of Federick (2010) for rabbits fed diets with inclusions of Moringa leaves. The weight of the internal organs across the treatments in this study were better than values of rabbits fed cowpea and soybean hull based diet (Orji, 2009). Ahamefule *et al*., (2006) reported that the weights of some internal organs like kidney and liver may be used in animal feeding experiments as evidence of toxicity. The values obtained for the internal offals in this study were within the normal range, hence indicating that there were no abnormalities or pathological lesions in these organs, thus confirming no toxicity in the treatment diets.

## Conclusion

It could be concluded that BWMO had positive effect on the feed intake, weight gain, nutrient digestibility, blood components and carcass qualities of rabbits. Therefore further studies into the utilization of bread wastes as supplemental feed source for rabbits especially in the dry season is required. .

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# IN VITRO FERMENTATION AND RUMEN MICROBIAL COUNT OF WEST AFRICAN DWARF GOATS FED GARLIC (ALLIUM SATIVUM) POWDER

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## Abstract:

The experiment was carried out to evaluate the effect of garlic (A. Sativum) powder on in vitro fermentation kinetics and rumen microbial count of West African Dwarf (WAD) goats. Garlic cloves were oven dried, ground into powder and used to formulate four experimental diets containing 0, 0.5, 1.0 and 1.5% garlic powder (Control, GP0.5, GP1.0, and GP1.5 respectively). Rumen fluid was collected from five goats prior to morning feeding from animals that were offered Panicum maximum and concentrate diet. The rumen fluid was put in a thermo flask pre-warmed to a temperature of 39°C. The substrate used was a mixture experimental diet and Panicum maximum at ratio of 30:70. The samples were incubated for 48 hours at 39°C after which 4 ml NaOH was introduced to estimate methane production. Rumen contents from animals which had been fed the experimental diets above with Panicum maximum as basal diet at ratio 30:70 for 84 days were collected for microbial count. Results obtained indicated that garlic powder supplementation significantly ($p<0.05$) increased metabolizeable energy and short chain fatty acids while also decreasing significantly ($p<0.05$) methane production. In vitro dry matter digestibility (IDMD), organic matter, potential gas production (a), gas production rate constant (c) and time of incubation (t) were not significantly ($p>0.05$) affected by garlic powder supplementation. The protozoa counts significantly ($p<0.05$) decreased with increased garlic powder supplementation. Bacteria and fungi counts were not significantly ($p>0.05$) affected by garlic powder supplementation. The results of this study concluded that feeding of garlic powder to WAD goats at 1.5% reduced methane output by 64.9% under in vitro conditions.

**Key words:** WAD goats, Methane, Garlic powder, Bacteria, Fungi, Protozoa

## Introduction

The demand for clean, green and ethical animal production systems is a challenge currently posed on livestock production (Martin *et al*., 2004). Strategies employed to deal with this challenge involves limited use of drugs, chemicals and hormones in order to reduce the impact of livestock production on the environment while also considering the welfare of the animal. Animal nutritionists have made attempts to manipulate rumen fermentation not just to improve digestibility but also to reduce methane emissions and nitrogen excretion (Patral *et al*., 2006). There is an increasing awareness of the contribution of greenhouse gases to climate change. Methane (CH4) is one of the most important greenhouse gases as it has a global warming potential 25 times greater than that of carbon dioxide over a 100-year time frame (Shindell *et al*., 2009). In recent times attention has been given to evaluating the potential of natural antimicrobials such as herbs and plant extracts in mitigating methane production from livestock. These herbs and plant extract have been shown to manipulate ruminal fermentation ( defaunation, decrease methane, reduce ruminal degradation of dietary protein) and improve nutrient utilization in ruminants ( Busquet *et al*., 2005; Patral *et al*., 2006; Wanapat *et al*., 2008a) whic can also be a cost effective way to improve performance of small ruminants. Plant herbs such as garlic are widely used to maintain the microbial ecosystem of the gastro-intestinal track especially in tropical regions. Garlic has been studied as aqueous or ethanol extracts as well as dried powder (Shin and Kim 2004) as it contains high level of organosulphur compounds such as allicin, ajoene, s-ally cysteine, di-ally disulphide and methyl cysteine sulfoxide (Chi *et al*., 1982). A study with garlic has reportedly improved rumen fermentation and energy utilization in WAD sheep under in vitro condition (Adewumi, 2008). Also studies from different researchers indicated a significant reduction in methane output under in vitro condition (Benchaar *et al*., 2006; Hart *et al*., 2006; Adewumi, 2008; Wanapat *et al*., 2008; Zafaria and Mustafi 2013). Mitigation of competition between different microbial populations to improve the efficiency of energy and protein in the rumen can achieved by optimizing diet formulation and use of feed additives that alter the environment and increase or decrease in specific microbial populations in the rumen (Calsamiglia *et al*., 2006). The effect of garlic on microbial count has also been reported (Calsamiglia *et al*., 2006; Wanapat *et al*. 2013). However there is need to validate these results in different species of livestock, different environmental conditions and different forms under which garlic can be utilized; hence this research evaluated the potential use of garlic powder in methane mitigation and microbial count of WAD goats.

## Materials and Methods

*Experimental Site*

The field work was carried out at the Small ruminant unit of the Directorate of University Farms (DUFARMS), while the Laboratory aspects were carried out at the Pasture and Range Management Laboratory, College of Animal Science and Livestock Production as well as Microbiology Laboratory, College of Natural Science, located within latitude 7° 13' N and longitude 3° 26' E (Google Earth, 2016), Federal University of Agriculture, Abeokuta, Ogun State, Nigeria.

*Experimental animals and management*

Twenty West African dwarf (WAD) bucks of between 6-7 months with average live weight of 5-8 kg were sourced from a small holder goat farm at Camp, Abeokuta for this study . They were housed individually in an experimental pen with aluminum roofing sheet and raised slatted floor. From the first day of the study, animals were fed twice daily at 9.00 am and 2.00 pm based on 5% body weight. They were offered basal diet (Panicum maximum) at

*Experimental design and procedures*

The experimental procedures were divided into two experiments (1 and 2):

Experiment 1 was to determine the

effect of varying levels of garlic (*A. Sativum*) powder on invitro gas fermentation and other kinetics. The study was a complete randomized design with four dietary treatment groups (Table 1). Rumen fluid was collected from five goats prior to morning feeding from animals that were fed with Pannicum maximum and concentrate diet containing palm kernel cake, wheat offal, Maize, bone meal, salt and vitamin premix using suction tube as described by Babayemi and Bamikole (2006), into a thermo flask that has been pre warmed to a temperature of 39°C. The buffer solution used was 9.8NaHCO3 + 2.77 NaPO4 + 0.57 KCl + 0.47 NaCl +2.16 MgSO4.7H2O +0.16CaCl2.2H2O. Incubation procedure was as reported by Menke and Steingas (1998) using 100 ml calibrated transparent glass syringes fitted with silicon tube. Eight (8) replicates each of 200 mgDM oven-dried and milled sample mixtures of grass and experimental concentrate diet (140 mg: 60 mg) was loaded in the syringes, the rumen fluid and the buffer were mixed together in ratio 1:2(v/v). 30 ml of inoculum were drawn and dispensed into the calibrated transparent syringes containing the substrate (grass/concentrate mixture) under continuous CO2 flushing. Air bubbles were removed from the syringes by gently tapping the syringes and pushing the piston upwards to expel the air. The silicon tubes on the syringes were properly clipped to prevent escape of gas before placement into the incubator. The glass syringes were placed in the incubator at a temperature of 39°C for gas production, which was measured at 3, 6, 9, 12, 18, 24, 30, 36, 42, 48 hrs. At post incubation period, 4ml NaOH was introduced into incubated samples to estimate methane production as reported by Fievez *et al*. (2005). ME (MJ/KgDM) and OMD was estimated as established by Menke and Steingas (1998) and SCFAs was calculated as reported by Gatechew *et al*. (1998). Total gas volume (GV) was expressed as ml/200mgDM, CP and ash as g/kg DM, ME as MJ/kg DM and SCFA as µmol/g DM.

Experiment 2 was to determine the effect of garlic (*A. Sativum*) powder on the rumen microbial count of WAD goats. The study was a complete randomized design with four dietary treatments (Table 1). The animals were fed experimental diet and Pannicum maximum at ratio 30:70 for 84 days.

*Data collection*

Determination of In vitro dry matter digestibility (IDMD), Metabolizable energy (ME), Organic matter digestibility (OMD), Short chain fatty acids (SCFA)

After 48 hours digestion, the syringe content was emptied into pre weighed crucibles and oven dried at 105°C for 24 hours. The dry residues were weighed and the digestibility calculated as percentage of the initial DM input. ME and OMD were calculated using the formulae :

$$ME=2.20+0.136Gv-0.057CP+0.0029CF$$
$$OMD=14.88+0.889Gv+0.45CP + 0.0651XA$$
$$SCFA=0.0239Gv-0.0601$$

Where Gv is Net gas production (ml/200mg DM)
CP is Crude protein
CF is Crude fibre
XA is ash

*In vitro fermentation kinetics.*

Cumulative gas production data were fitted to non-linear exponential model as:

$$Y= A\ (1\text{-}exp\text{-}ct)$$

Where Y is gas production at time't', A is the volume of gas produced with time (ml/200 mgDM), c is the gas production rate constant (h-1) and t is the incubation time (h).

*Determination of rumen microbial count*

Rumen fluid was collected from four animals per treatment at the end of the experiment 6 hours post feeding. Rumen fluid was immediately measured for pH using a portable pH meter. Samples of fermented rumen fluid was transferred to a plastic bottle for which 9ml of 10ml/L formalin solution (1:9 v/v) had been added and then stored at 4°C for measurement of bacteria, fungal zoospores

**Table 1:** Ingredient composition (%) of experimental concentrate diet fed to WAD goats

| Ingredients | Control | GP0.5 | GP1.0 | GP1.5 |
|---|---|---|---|---|
| Palm kernel cake | 32.00 | 32.00 | 32.00 | 32.00 |
| Wheat offal | 34.00 | 34.00 | 34.00 | 34.00 |
| Maize | 30.00 | 29.50 | 29.00 | 28.50 |
| Bone meal | 3.00 | 3.00 | 3.00 | 3.00 |
| Salt | 0.50 | 0.50 | 0.50 | 0.50 |
| Vitamin premix | 0.50 | 0.50 | 0.50 | 0.50 |
| Garlic powder | 0.00 | 0.50 | 1.00 | 1.50 |
| **Total** | **100** | **100** | **100** | **100** |
| **Determined analysis** | | | | |
| Crude protein | 14.01 | 13.13 | 12.96 | 12.25 |
| Neutral detergent fibre | 41.68 | 56.30 | 59.58 | 63.37 |
| Acid detergent fibre | 40.23 | 43.56 | 48.65 | 51.34 |

*GP0.5- Garlic (A. sativum) powder at 0.5% level of inclusion*
*GP1.0- Garlic (A. sativum) powder at 1% level of inclusion*
*GP1.5- Garlic (A. sativum) powder at 1.5% level of inclusion*

**Table 2:** Selected chemical composition (%) of substrate used for in vitro fermentation

| Parameters | Control | GP0.5 | GO1.0 | GP1.5 |
|---|---|---|---|---|
| Dry matter | 90.82 | 91.07 | 92.32 | 93.30 |
| Crude protein | 12.88 | 12.49 | 12.36 | 12.25 |
| Crude fibre | 19.86 | 20.04 | 20.11 | 20.35 |
| Ash | 10.47 | 10.71 | 11.22 | 11.37 |

*GP0.5- Garlic (A. sativum) powder at 0.5% level of inclusion*
*GP1.0- Garlic (A. sativum) powder at 1% level of inclusion*
*GP1.5- Garlic (A. sativum) powder at 1.5% level of inclusion*

**Table 3:** Effect of varying levels of garlic (Allium sativum) powder supplementation on in vitro digestibility kinetics

| Parameters | Control | GP0.5 | GP1.0 | GP1.5 | SEM |
|---|---|---|---|---|---|
| IDMD | 65.23 | 67.25 | 68.11 | 58.33 | 4.31 |
| OMD (%) | 68.47 | 84.32 | 79.55 | 76.25 | 2.62 |
| ME (MJ/kgDM) | 8.62$^{b}$ | 11.15$^{a}$ | 10.37$^{ab}$ | 9.87$^{ab}$ | 0.41 |
| a (ml/200mgDM) | 27.65 | 15.54 | 15.54 | 15.54 | 3.03 |
| c (ml/hr) | 1.22 | 1.65 | 1.73 | 1.70 | 0.14 |
| t (hr) | -5.96 | 0.70 | 0.66 | 0.67 | 1.65 |
| Methane (mM/200mgDM) | 34.25$^{a}$ | 29.25$^{b}$ | 19.00$^{c}$ | 12.00$^{d}$ | 2.28 |
| SCFA (µmol/gDM) | 1.20$^{b}$ | 1.64$^{a}$ | 1.51$^{ab}$ | 1.42$^{ab}$ | 0.07 |
| Total GV (ml/200mgDM) | 47.33$^{b}$ | 71.00$^{a}$ | 65.67$^{a}$ | 62.00$^{a}$ | 3.20 |
| CH4:GV ratio (%) | 75.34$^{a}$ | 42.43$^{b}$ | 30.00$^{c}$ | 19.02$^{d}$ | 6.38 |

*$^{ab}$ Means with different superscript on the same row differ significantly (P<0.05)*
*GP0.5- Garlic (A. sativum) powder at 0.5% level of inclusion*
*GP1.0- Garlic (A. sativum) powder at 1% level of inclusion*
*GP1.5- Garlic (A. sativum) powder at 1.5% level of inclusion*
*SCFA - Short chain fatty acids*
*GV- Gas volume after 48 hours incubation*
*IDMD- In vitro dry matter digestibility*
*OMD- organic matter digestibility*
*ME- Metabolisable energy*
*a- volume of gas produced*
*c- gas production rate constant*
*t- incubation time*

**Table 4:** Effect of varying levels of garlic powder supplementation in diet of WAD goats on rumen microbial count

| Parameters | Control | GP0.5 | GP1.0 | GP1.5 | SEM |
|---|---|---|---|---|---|
| Protozoa count(cells/ml) | 65.25[a] | 46.25[b] | 19.25[c] | 5.25[d] | 6.24 |
| Bacterial count(cfu/ml)×105 | 1.84 | 1.90 | 2.10 | 2.30 | 0.16 |
| Fungi count(cfu/ml)×103 | 5.48 | 4.43 | 5.15 | 4.83 | 0.43 |

*abcd Means with different superscript on the same row differ significantly (P<0.05)*
*GP0.5- Garlic (Allium sativum) powder at 0.5% level of inclusion*
*GP1.0- Garlic (Allium sativum) powder at 1% level of inclusion*
*GP1.5- Garlic (Allium sativum) powder at 1.5% level of inclusion*

and the protozoa populations using Hungate (1969) roll-tube technique for bacteria and Galyean (1989) by haemocytometer for fungi. Protozoa count was done by a direct count using a microscope at 10× magnification.

*Statistical analysis*

The data generated were subjected to Analysis of Variance in Completely Randomized Design using SAS (2010) statistical software and differences in means separated using Duncan's Multiple Range Test at (P<0.05) level of probability.

## Results

*Effect of varying levels of garlic powder supplementation in diet of WAD goats Selected proximate composition of substrate*

The proximate composition of substrate used for in vitro fermentation is shown in Table 2. Dry matter content of the substrate ranged between 90.82 % in the control to 93.30 % in the GP1.5 group. Crude protein values were from the range of 12.88% in the control and 12.36 % in GP1.0. Crude fibre was least in the control with a value of 19.86 % and highest in GP1.5 with a value of 20.35 %. Ash content in the substrate also increased with increasing amount of garlic powder inclusion and was found to be in the range of 10.47 % and 11.37 %.

*Effect of varying levels of garlic powder supplementation on in vitro digestibility kinetics*

The result of effect of varying levels of garlic powder supplementation on in vitro digestibility kinetics is shown in Table 3. Garlic inclusion had no (P>0.05) influence on all the in vitro digestibility kinetics measured except methane (CH4) output, Gas Volume (GV), CH4: GV ratio, Metabolizeable energy, and short chain fatty acids. The significantly different Metabolizeable energy ranged from 8.62 to 11.15 MJ/kgDM. The highest value was observed in the GP0.5 group (11.15 MJ/kgDM) while the lowest mean value (8.62 MJ/kgDM) was observed in control group. Methane production was significantly (P<0.05) different across treatment groups. Control group had the highest methane output (34.25 mM/kgDM) with GP1.5 group having the least value (12.00 mM/kgDM). Short chain fatty acids (SCFA) significantly (P<0.05) increased with increasing level of garlic inclusion. SCFA values ranged between 1.20 µmol/gDM to 1.64 µmol/gDM with GP0.5 having the highest value (1.64 µmol/gDM) while the control group had the least value (1.20 µmol/gDM). Gas volume was significantly (P<0.05) higher in the supplemented group compared to the control group. The highest amount of gas volume was observed to be 71.00 ml/200mgDM in the GP0.5 group with the least value of gas volume found to be 47.33 ml/200mgDM in the control. Methane to gas volume ratio expressed in percentage significantly (P<0.05) decreased with increasing amount of garlic powder supplementation. While the highest value of 75 % was observed in the control group, the GP1.5 group had the least value of 19.02 %. In vitro dry matter digestibility (IDMD) was not statistically (P>0.05) significant, GP0.5 group had numerically higher value (68.11%) while the control had the least value of 65.23%.

496 Ikyume TT, Sowande O S, Dele P A, Yusuf A O, Monday S, Egunjobi O K and Fatoba T The non-significantly in vitro organic matter digestibility (OMD) ranged between 68.47% and 84.32%. The highest percentage OMD was observed in the GP0.5 group while the control group had the least value of 68.47%. Potential gas production (a) did not show any significant (P>0.05) difference in this study and ranged between 15.54-27.65 ml. The highest value of 27.65 ml was observed in the control group with all supplemented groups having a similar value of 15.54 ml. Rate of gas production-constant (c) was also observed not to be significant (P>0.05) across treatment groups and ranged between 1.22-1.73 ml/hr. The highest rate of gas production was observed in the GP1.0 group (1.73 ml/hr) with the least value recorded in the control group (1.22 ml/hr). Incubation time (t) was not significant (P>0.05) across treatment groups and ranged between -5.96-0.7 hr. The highest incubation time was recorded in the GP0.5 group with the least time found to be in the control group.

*Effect of varying levels of garlic powder supplementation in diet of WAD goats on rumen microbial count.*

The effect of varying levels of garlic (A. sativum) powder supplementation in diet of WAD goats on rumen microbial count is as shown in Table 4. There was a significant (P<0.05) difference in the protozoa count among treatment group with the highest count observed to be 65.25 cells/ml in the control group while the least value of 5.25 cells/ml was observed in the GP1.5 group.

The viable bacterial count and fungi count were not significantly (P>0.05) affected by the inclusion of garlic powder in the diet of WAD goats. Bacterial count was found to increase (P>0.05) numerically across treatment group as the level of garlic powder supplementation increased. The highest count was recorded in the GP1.5 group with the value of 2.30×105 cfu/ml while the least value was observed in the control group to be 1.84×105 cfu/ml.

The non-significantly (P>0.05) fungi count did not follow a definite pattern. The highest value of 5.48×103 cfu/ml was observed in the control group while the least value was observed in the GP0.5 group to be 4.43×103 cfu/ml.

## Discussion

Crude protein content of the substrate exceeds the minimum recommended range of 7.0-8.0 % for efficient functioning of rumen micro organism (Van Soest, 1994), it however fell within the range of 11-13 % known to be adequate of supporting maintenance and moderate growth in goats (NRC 1981; Poppi and McLenna, 1995; Sinn, 1992). Crude fiber levels in the substrate were higher than the 16-18 % levels recommended for goats by Sinn (1992) and the 15 % CF recommended by Ayoade (2010) for non-lactating goats. High levels of fibre have been acknowledged (McDonald *et al*., 1995) to be inversely related to feed digestibility and nutrient availability.

The in vitro gas production technique is a useful tool in determining the nutritional value of feeds because the volume of gas produced reflects the end products of the fermentation of its substrates to volatile fatty acids, microbial biomass and neutralization of VFA, thereby demonstrating the nutritional value of such feed (Blumel and Becker, 1997). In vitro methane production reduced significantly with supplementation of garlic powder. The reduction in methane could be attributed to the action of garlic powder compounds on ciliate protozoa which have a symbiotic relationship with Methanogens which are responsible for 9.25% of methanogenisis in the rumen (Newbold et al., 1995). Result of methane output obtained in this present study agree with report of Adewumi (2008) who found a reduction in methane output when garlic powder was included in diet of west African dwarf sheep. Also, Zafarian and Manafi (2013) reported a 31% reduction in methane production when garlic powder was supplemented in diet of lactating buffalo under in vitro and in vivo. Several other researchers

have reported a significant reduction in methane output through administration of garlic and/or its compounds (Benchaar *et al*., 2006; Hart *et al*., 2006; Wanapat *et al*., 2008a). Gas volume (Gv) significantly increased with higher levels of garlic powder inclusion in the substrate. Although gas production is regarded as nutritionally wasteful (Mauricio *et al*., 1999), it however provides a useful basis from which metabolizable energy, organic matter digestibility and short chain fatty acid can be predicted (Babayemi *et al*., 2006). The increase in gas volume in this present study was however proportionate with increase in short chain fatty acid and Metabolizeable energy which is an indication of feed digestibility. Results of gas production in this study is in agreement with that of Adewumi (2008) who reported a significant increase when 1.25 % inclusion level of garlic powder was utilized under in vitro condition in sheep. Fievez *et al*. (2005) also reported in vitro gas production to be synonymous with feed digestibility, so that the higher the gas production the higher the digestibility (Ajayi and Babayemi, 2008). Metabolizeable energy (ME) and short chain fatty acid (SCFA) in this study also increased significantly ($P<0.05$) with the inclusion levels of garlic powder. This implies that garlic powder inclusion provides increased availability of energy for the animals and ruminant micro-organism. The significant increase in SCFA and ME is consistent with reports by Adewumi (2008) that indicated an increase in SCFA and ME by garlic supplementation in WAD sheep under in vitro condition. He attributed the increase in ME and SCFA to increased availability of energy to ruminants' microorganism. The numerically increased OM, t and c agrees with report by Adewumi (2008). Yang *et al*. (2007) also reported increased ruminal digestibility of dry matter and organic matter with garlic supplementation.

The significant decrease in the protozoa count with increase in garlic powder supplementation is likely to affect the level of methane output given that protozoans have a symbiotic relationship with Methanogens. As the amount of garlic supplementation increased, the protozoa count decreased. Greathead (2003) postulated that many essential oils from herbs have dose dependent effect on

bacteria, protozoa and fungi. The result of this present study agree with result of several researchers on the effect of garlic on rumen protozoa ( Wanapat *et al*., 2013; Kongnum *et al*., 2010; Amagase *et al*., 2001; Patra *et al*., 2010; Tao *et al*., 2016). Correlation between plant extract (garlic) and protozoa number might be explained by the low capability of permeable properties of their cell membrane (Wanapat *et al*., 2013). Wanapat *et al*. (2008b) also reported similar trend in result with garlic powder supplementation which tended to decrease protozoa count.

The viable bacterial and fungi counts were not significantly ($P>0.05$) affected by the inclusion of garlic powder in the diet of WAD goats. While increased levels of garlic powder supplementation numerically increased the bacteria count, the fungi count slightly decreased with garlic powder supplementation. A non significant result for bacteria and fungi count obtained in this present study agrees with reports of other researchers (Kongnum *et al*., 2010; Wanapat *et al*., 2013).

Impact

The utilization of garlic (A. sativum) powder in feeding of Livestock in order to mitigate methane production thereby reducing the contribution of Livestock to global warming.

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# BLOOD TUMOR NECROTIC FACTOR-ALPHA, *ERYTHROPOIETIN* AND *INTERLEUKIN-9* IN THE PATHOGENESIS OF ACUTE *Anaemia* IN *TRYPANOSOMA CONGOLENSE* INFECTED RABBITS.

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## Abstract

African Animal Trypanosomosis (AAT) is a protozoan disease caused by Trypanosoma congolense, T. vivax and T. brucei. *Anaemia* and dsyhaemopoiesis is a major clinical sign of AAT, and its pathogenesis is yet to be fully understood. This study evaluated the possible roles of blood Tumor Necrotic Factor-Alpha (TNF-∝), Erythropoietin (EPO) and Interleukin-9 (IL-9) in the pathogenesis of acute *anaemia* in Trypanosoma congolense infected rabbits. Twelve adult rabbits of both sexes with mean weight of 0.80 ± 0.2kg were randomly assigned into two groups of six rabbits each. Group A rabbits were intraperitoneally (i.p) infected with blood containing (0.5 ml)2 x 106/ml of *T. congolense*, while group B (control) rabbits were injected with 0.5 ml of normal saline i.p. Blood was collected from the ear vein before infection and weekly thereafter for four weeks post-infection (p.i), in order to determine the Packed Cell Volume (PCV), Haemoglobin (Hb) concentration, Red Blood Cell (RBC) count, Reticulocyte Count (RET), serum concentrations of TNF-∝, EPO and IL-9. The PCV, RBC count and Hb concentration were significantly ($p<0.05$) lower in group A than group B rabbits one week p.i. till the end of the study. Serum concentration of EPO and TNF-∝ had a significant ($p<0.05$) increase at week 3 and week 4 p.i. respectively as against the control. Serum concentration of IL-9 had a sudden significant ($p<0.05$) decline from 22.05± 0.9ng/ml to 8.3± 0.6ng/ ml at week 3 p.i. The serum concentration of EPO and TNF-∝, RET and TNF-∝, EPO and RET had a positive but not significant ($p>0.05$) correlation, EPO and IL-9 had a negative significant ($p < 0.05$) correlation ($r= -0.987$). The study concluded that ineffective erythrocytic response to the *anaemia* in experimental *T. congolense* infected rabbits is associated with the increased and decreased serum levels of TNF-∝ and IL-9.

**Keywords:** African Animal *Trypanosomosis*, *Trypanosoma congolense*, *Anaemia*, Tumor Necrotic Factor-Alpha, *Erythropoietin* and Interleukin-9.

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## Introduction

African Animal Trypanosomosis (AAT) is an important disease of domestic livestock in sub-Saharan Africa caused by Trypanosoma congolense, T. vivax and T. brucei which are flagellate protozoans that inhabit the blood, lymph and various tissues of their hosts. They belong to the Genus Trypanosoma, Order Kinetoplastida and Family Trypanosomatidae (Ilemobade, 2009; Taylor & Authié, 2004)

A significant pathological feature of African trypanosomosis is severe *anaemia* (Omotainse, 1997; Omotainse & Anosa, 1992) which develops very early in infection around the time when parasites become detectable in the blood and the *anaemia* persists after the first waves of parasitaemia when low numbers of trypanosomes are circulating in the blood (Losos & Ikede, 1972; Takeet & Fagbemi, 2009), this gives the assumption that the *anaemia* is not directly induced by the parasite factor only but might be cytokine mediated as in other cases of *anaemia* accompanying inflammation (Naessens *et al*., 2005). *Anaemia* in African Animal trypanosomosis is caused by variety of mechanisms which include: ineffective retention of iron and erythrocyte destruction by the mononuclear phagocytic system (haemolytic *anaemia*) and ineffective erythropoiesis, although the mechanism remains not fully understood (Kaikabo & Salako, 2006; Omotainse, 1997; Witola & Lovelace, 2001; Wolkmer *et al*., 2009). *Anaemia* of inflammation is immune mediated by cytokines and cells of the reticuloendothelial system which induce changes in iron homeostasis, the proliferation of erythroid progenitor cells, the production of erythropoietin, and the lifespan of red cells, all of which contribute to the pathogenesis of *anaemia* (Yap & Stevenson, 1994). Tumour Necrosis Factor (TNF∝) negatively affect effectiveness of rh-EPO therapy (Macdougall & Cooper, 2002; Stenvinkel, 2001) and has been shown to suppress erythropoiesis in vitro (Allen, Breen, Yaqoob, & Macdougall, 1999; Dai, Price, Brunner, & Krantz, 1998; Means & Krantz, 1992). There is strong evidence that *anaemia* of inflammation is mediated by TNF-∝ and other inflammatory cytokines (Jelkmann, 1998). Erythropoiesis is the process by which red blood cells (erythrocytes) are produced. It is stimulated by decreased oxygen in circulation, which is detected by the kidneys, which then secrete the hormone erythropoietin (EPO), a 34-kDa glycoprotein (Nishimura *et al*., 2011).

Interleukin-9 (IL-9) is a multifunctional cytokine secreted by T helper 2 lymphocytes differentiation of mast cells and hematopoietic progenitors (Demoulin & Renauld, 1998; Levitt *et al*., 1999). In an experiment conducted by Bourette *et al*., (1992) , murine interleukin 9 (mIL-9) stimulated erythroid burst-forming units (BFU-E) from murine bone marrow and it also favoured erythroid differentiation of these cells in the presence of erythropoietin (Bourette, Royet, Mouchiroud, Schmitt, & Blanchet, 1992).

Previous research findings have shown that the erythropoiesis induced following *anaemia* in *T. congolense* infection is inadequate (Anosa & Kaneko, 1983; Omotainse & Anosa, 1992). Further investigations revealed insignificant increase in erythropoiesis with a corresponding rise in erythropoietin in *T. congolense* infected cattle (Suzuki *et al*., 2006). Therefore, erythropoiesis in trypanosomosis is ineffective (Taylor & Authié, 2004) and the underlying mechanism is still not fully understood (Kaikabo & Salako, 2006; Witola & Lovelace, 2001; Wolkmer *et al*., 2009). Buza *et al*. (1995) suggested that the ineffective erythroid response in the face of elevated erythropoietin concentration in *bovine* trypanosomosis may be as a result of the presence of inhibitory factors (Buza, Logan-Henfrey, Andrianarivo, & Williams, 1995). These factors include pro-inflammatory cytokines such as Tumour Necrosis Factor (TNF∝), and Interleukin-1 (IL-1) which had been shown to suppress erythropoiesis in vitro (Allen *et al*., 1999; Dai *et al*., 1998). This study aims at assessing the serum level of EPO, TNF-∝ and IL-9 during rabbit trypanosomosis and try to explain their role in the pathogenesis of *anaemia*.

## Materials and Methods

Twelve Chinchilla rabbits of both sexes (six males and six females) weighing between 0.80-1.00 kg and aged 8weeks were used for the study. The rabbitswere purchased from a breeder farm in Abeokuta, Ogun State at four weeks of age and housed in pairs in standard fly proof rabbit experimental cages in the experimental animal unit of the College of Veterinary Medicine, Federal University of Agriculture Abeokuta. The rabbits were prophylactically treated with Albendazole (A-Zole®) and Ivermectin (Kepromec®, Holland) at the rate of 5mg/kg body weight orally and 400 µg/kg body weight subcutaneously respectively and 20% Oxytetracycline injection (Tetroxyl®) was administered at 22mg/kg body intra-muscularly against helminths and haemoprotozoan infections. They were fed with rabbit pellets (Vita Feeds®, Grand Cereals, Jos, Nigeria) and water ad libitum. The study followed the humane method for handling animals as outlined by CACC, 1993 and was approved by research ethical committee with reference number FUNAAB/ COLVET/ REC. 16/ 02. They were left to acclimatized for four weeks before the commencement of the experiment. During the period of the acclimatization, the rabbits were screened weekly for gastrointestinal and blood parasitic infections.

A simple control randomized experimental study comprising of two groups (GroupsA and B) with six animals per group was conducted. Group A rabbits were infected with Trypanosoma congolense 2 x 106 trypanosomes in 1ml of blood and Group B rabbits were given 1ml of normal saline and served as uninfected control.

Already characterized Trypanosoma congolense was obtained from the reference laboratory parasite bank of the Nigerian Institute of Trypanosomiasis Research (NITR), Vom, Plateau State, Nigeria was used for this study.

Rectal temperature of the rabbits were measured and recorded daily, with a digital thermometer (Vcare®, China) and a thick blood smear was used to screen for

Parasitaemia daily post infection. At the unset of *anaemia*, blood (1.0ml) was collected from rabbits through aseptic venipuncture of the ear vein; 0.5ml was put into sodium ethylene diaminetetra acetic acid (EDTA) bottle for parasite determination, complete blood count and 0.5ml into plain bottle for the determination of serum concentration of cytokines. This was repeated weekly over a period of 28 days. At the end of the experiment, infected rabbits were treated with diminazene aceturate (Veriben®) at 3.5mg/kg. Haematological indices such as packed cell volume (PCV), haemoglobin concentration, total red blood cell (RBC) and absolute reticulocyte were determined according to Jain (1986). TNF-$\propto$ was assayed using rabbit TNF$\propto$ ELISA kit (MyBiosource®, USA), EPO was assayed using a commercial (Abcam® EPO Mouse, USA) ELISA kit and IL-9 was assayed using (MyBiosource®, USA) rabbit IL-9 ELISA kit.

*Statistical analysis*

Data collation was done in Microsoft Excel while Statistical Packagefor Social Sciences (SPSS. 17) was used for statistical analysis. Data were presented as means ± standard error of mean (SEM) and analyzed using 2-way analysis of variance (ANOVA). Relationships between parameters were determined using Pearson correlation. Values of $p<0.05$ was considered significant.

## Results

Parasitaemia was first observed with thick smear 4-7 days post infection (p.i) in the *T. congolense* infected group. The pre-infection PCV values were 44.3 ± 1.5% for the control group and 43.2 ± 2.1% for *T. congolense* group. These values decreased progressively but gradually till the termination of the experiment. *T. congolense* group had the lowest PCV (31. ± 1.8%) at week four p.i. Throughout the four-week period of the experiment, PCV values remained significantly ($p < 0.05$) lower than the pre-infection value (Figure 2). Pearson's correlation of the *T. congolense* group showed a negative but not significant ($p > 0.05$) correlation ($r= -0.758$) between PCV and

TNF-∝, negative but not significant (p > 0.05) correlation between PCV and EPO correlation (r= -0.825), positive but not significant (p > 0.05) correlation (r= 0.839) between PCV and IL-9.

The pre-infection RBC counts were 7.1 ± 0.3×1012/l of blood for the control group and 7.0 ± 0.2×1012/l of blood for *T. congolense* group. Seven days p.i., there was a significant (p < 0.05) decrease in the RBC counts of *T. congolense* group (6.4 ± 0.4×1012/l). The RBC counts significantly (p < 0.05) remained lower than the pre-infection levels throughout the experiment. (Figure 3).

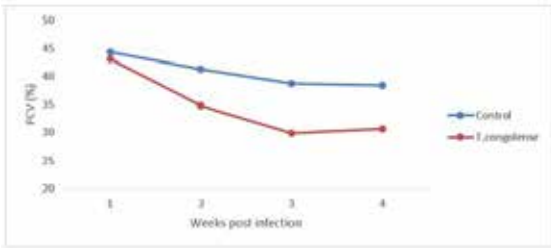



**Figure 2:** Mean Packed Cell Volume of *T. congolense* infected and control rabbits.

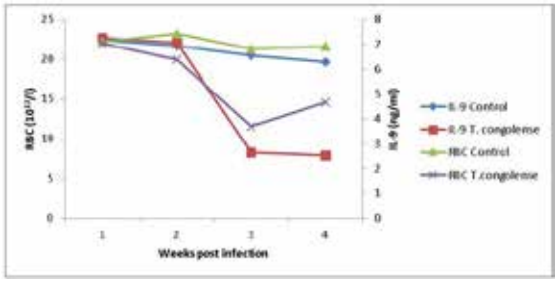



**Figure 3:** Mean Red Blood Cell count and *Interleukin*-9 concentration in *T. congolense* infected and control rabbits.

The mean absolute reticulocyte (RET) counts pre-infection were 2.5 ± 0.4×1011/l for the control group and 2.3 ± 0.4×1011/l for the *T. congolense* group. *T. congolense* group had a significant (p < 0.05) progressive increase in RET count from week one p.i (2.9± 0.3×1011/l) peaked at week two p.i (5.4 ± 0.3×1011/l), then gradually decreased to 3.6 ± 0.4×109/l at week four p.i.. During the period of the experiment, absolute RET count values remained significantly higher (p < 0.05) than the pre-infection level in the *T. congolense* group when compared with the non-infected group (figure 5). Pearson's correlation of the *T. congolense* group showed a positive but not significant (p > 0.05) correlation (r= 0.336) between RET and TNF-∝, positive but not significant (p > 0.05) correlation (r=0.881) between RET and EPO, negative significant (p < 0.05) correlation (r=-0.806) between RET and IL-9.

The mean corpuscular volume (MCV) of 62.5 ± 1.0fl and 61.4 ± 1.4fl were for control group and *T. congolense* group respectively prior to infection. Following infection, the mean MCV values of *T. congolense* infected rabbits increased significantly (p < 0.05) at week 2 and 4 when control was compared (Figure 4).

The pre-infection Mean Corpuscular Haemoglobin Concentration (MCHC) was 35.0 ± 2.1g/dl and 35.5 ± 1.9g/dl for the control and *T. congolense* respectively. There was a significant (p < 0.05) decrease in mean MCHC *T. congolense* infected rabbit groups when compare to the control at week four p.i.At the end of the experiment 28 dpi the mean MCHC were 35.3 ± 1.4g/dl and 33.2 ± 1.1g/dl for the control and *T. congolense* respectively (Figure 4). The mean pre-infection serum TNF-∝ concentration in the control group and *T. congolense* group were 51.0 ± 5.8ng/ml and 50.4 ± 6.4ng/ml respectively. The Sera TNF-∝ levels of the *T. congolense* group a significant (p < 0.05) increase was seen at week four p.i. (143.3 ± 8.2ng/ml) when compared to the control group. The Serum TNF-∝ levels of the control group were relatively stable throughout the experiment with 55.0 ± 6.1ng/ml, 53.7 ± 8.2ng/ml and 51.3 ± 8.2ng/ml at weeks 2, 3 and 4 (Figure 7).

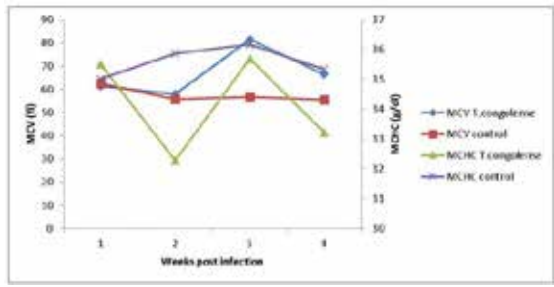



**Figure 4:** Mean Corpuscular Volume and Mean Corpuscular Haemoglobin Concentration in *T. congolense* infected and control rabbits

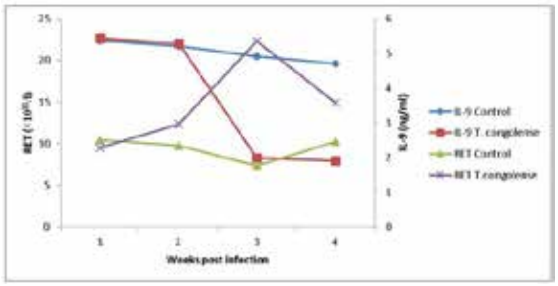



**Figure 5:** Mean Reticulocytes count and *Interleukin*-9 concentration in *T. congolense* infected and control rabbits.

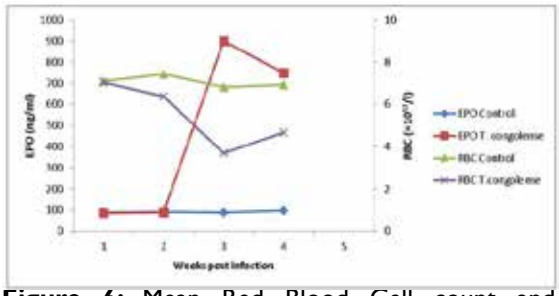



**Figure 6:** Mean Red Blood Cell count and *Erythropoietin* concentration in *T. congolense* infected and control rabbits.

The mean pre-infection IL-9 concentration in the control group and *T. congolense* group were 22.4 ± 1.2ng/ml and 22.6 ± 0.9ng/ml respectively. The levels decreased significantly ($p < 0.05$) in the *T. congolense* group post infection with 22.1 ± 0.9ng/ml, 8.3 ± 0.6ng/ml and 7.9 ± 1.2 ng/ml at weeks 2, 3 and 4 (Figure 5).

The *T. congolense* group had a significant ($p < 0.05$) decrease in concentration at week two p.i. and further drop at week three p.i. At week three p.i. *T. congolense* group had serum IL-9 concentration decreased (7.9 ± 1.2ng/ml). The mean pre-infection E P O concentration in the control and *T. congolense* were 88.8 ± 4.8pg/ml and 87.4 ± 4.3pg/ml respectively. The *T. congolense* infected rabbits group had a significant ($p < 0.05$) increase in EPO concentration on weeks two and three p.i. There was a significant difference in the concentration of EPO between week two and week three p.i. At week three p.i. *T. congolense* infected rabbits had EPO concentration of 749.0 ± 6.8pg/ml.

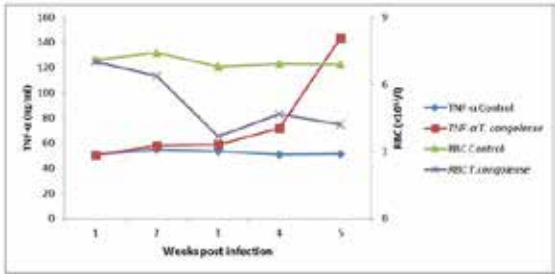



**Figure 7:** Mean Red Blood Cell count and Tumor necrosis factor-alpha concentration in *T. congolense* infected and control rabbits.

## Discussion

The *anaemia* observed in this study had a rapid unset and this is consistent with the findings of Losos and Ikede, (1972) and Omotainse (1997). The *anaemia* produced in *T. congolense* infected rabbits p.i was macrocytic normochromic except at weeks 1, 4 and 5 p.i where the *anaemia* was macrocytic and hypochromic but later became normocytic normochromic. The morphological changes in the *anaemia* of the infected rabbits agree with findings of Takeet and Fagbemi, (2009) in rabbits infected with *T. congolense*. The infected rabbits showed marked reticulocytosis at week 2 and 4 p.i which coincided with high MCV, and thus resulting in macrocytic *anaemia*, this is expected as the *anaemia* is regenerative.

Previous research has shown elevated TNF-∝ concentration to promote *anaemia* (Jelkmann, 1998) and inhibits the erythropoietic stimulatory effect of EPO (Stenvinkel, 2001; Macdougall and Cooper, 2002). In this study, there was a slight decrease in MCHC of the *T. congolense* group at weeks 1, and 4 p.i below the control group and this might have been due to the hyperactivity of the mononuclear phagocytic system which is a prominent feature in AAT (Anosa and Kaneko, 1983). In this study, *T. congolense* group had a negative correlation (r= -0.782) between TNF-∝ and haemoglobin concentration though not significant, this finding suggests that elevated TNF-∝ might have a negative effect on the haemoglobin concentration in trypanosomosis.

Omotainse and Anosa (1992) and Buza *et al.* (1995) advocated that the elevated

EPO concentration observed in *T. congolense* infection was not commensurate to the severity of the *anaemia* as observed and they proposed that this might have been because of anti-erythrocytic activities that inhibited the bioactivity of EPO (Buza *et al*., 1995). In this study, the control group had their absolute reticulocytes count between 1.16 – 2.93×1011/l. There was mild reticulocytosis at weeks 2 and 4 p.i (5.35± 0.31×1011/l and 4.02± 0.32×1011/l) in *T. congolense* infected group which coincided with severe *anaemia* and EPO peak. There was also a positive but not significant correlation (r= 0.620) between RET and EPO. These findings show that even though the *anaemia* was responsive the response was inadequate. There was a positive but none significant correlation (r= 0.336) between RET and TNF-∝ but a negative none significant correlation (r= -0.596) between TNF-∝ and RBC count. This might suggest to an extent that the elevation of TNF-∝ favours reticulocytosis but not maturation of the reticulocytes to RBCs. Also, observed in the infected group in this study was the concentration of TNF-∝ which had a positive but not significant correlation (r= 0.639) with EPO concentration, this may also suggest the reason behind the ineffective regenerative response to the *anaemia* produced by *T. congolense* infection.

IL-9 have been shown to enhance reticulocytes maturation (Bourette *et al*., 1992), in this study EPO concentration had a significant ($p<0.05$) negative correlation (r= -0.987) with IL-9 concentration. This could be the reason behind the inability of the elevated EPO concentration to produce a commensurate regenerative response as the declining IL-9 concentration produces a counter stimulatory erythropoietic effect.

In conclusion, *anaemia* produce as a result of experimental infection of rabbits with *T. congolense* was characterized a significant elevation EPO and TNF-∝ concentrations, and a significant decline in IL-9 concentration. The interactions between these factors demonstrated to an extent the reason behind the ineffective erythropoiesis observed in *T. congolense* infection. Further studies to evaluate the effects of other pro and anti-inflammatory cytokines in the pathogenesis of AAT is encouraged as this would lead effective prophylactic and therapeutic management of the disease.

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# CLINICO-HAEMATOLOGICAL AND BIOCHEMICAL FEATURES OF NATURAL *BABESIOSIS* IN NIGERIAN BREEDS OF CATTLE.

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## Abstract

This study evaluated the haematological and biochemical changes associated with *bovine Babesiosis*. A total of 50 samples confirmed positive for Babesia spp from305 sera collected from clinically suspected cases of *Babesiosis* within a period of 9 months from some cattle farms in Oyo state, southwest Nigeria. Breeds were established by their morphological features, Age was estimated using rostral dentition and sexes morphologically determined. Haematological and Biochemical analysis were established by adopting standard procedures and the use of specific kits respectively. Results showed 32 (64%) was White Fulani breed, 8 (16%) was Sokoto Gudali breed, 8 (16%) was Red Bororo breed and 2 (4%) was Kuri breed. Female with 43 (86%), while the male had 7 (14%) susceptibility. Older cattle (≥4yrs) with 27 (54%) susceptibility, (3-3½yrs) with 17 (34%) susceptibility, while (2-2½yrs) had the least susceptibility of 6 (12%).

Hematological analysis revealed best parameters in White Fulani breed with Mean ± SD of PCV 28.6 ±8.76, HB 9.3±2.98, RBC 7.5±2.44, while the least values were seen in Sokoto gudali breed with the following parameters; PCV 24.6±6.89, HB 8.1±2.29, RBC7.8±1.59. Biochemical analysis revealed White Fulani with the best values as follows; Total protein 5.5±1.87, Albumin 1.3±0.20, Globulin 4.2±1.73, Glucose 58.1±18.0, AST 60.3±15.68, ALT 50.7±14.80. For age group, the best parameters were observed in (3-3½yrs) group with the following; PCV 29.2±7.76, HB 9.4±2.72, RBC 7.6±2.52, Total protein 5.5±2.11, Glucose 56.9±20.31, AST 61.1±17.15 compared to age group 2-2½yrs with the following values; PCV 26.6±9.81, HB 8.3±3.28, RBC 7.1±2.27, Total protein 4.5±1.64, Glucose 49.3±20.85, AST 54±11.01. No significance difference in their indices except in blood urea nitrogen value which was significant among the breeds sampled. This investigation reveals variation in the susceptibility to natural *Babesiosis* among Nigerian cattle breeds, ages and sexes with generalise *anaemia*, *lymphocytopaenia*, *neutrophilia*, *hypoproteineimia*, hypoalbuminaemia and extremely low blood urea nitrogen.

**Keywords:** Clinical, Haematological, Biochemical, *Babesiosis*, Cattle, Nigeria

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## Introduction

*Babesiosis* is a condition caused by Babesia spp, which are protozoan parasites transmitted mainly by ticks and able to infect erythrocytes and/or leukocytes of a wide variety of domestic and wild animals. Babesia is next to trypanosomes among most common parasite found in the blood of mammals (Yabsley and Shock, 2013). Direct losses associated with *Babesiosis* include; morbidity, mortality, delayed growth, reduction in meat and milk yield and indirectly through cost of control measures of ticks (Gharbi *et al*., 2011). This infection is characterized by anemia, icterus, hemoglobinuria, and death. The infection is also characterized by fever (40-42°C) which may be sudden in onset, anemia, icterus, hemoglobinuria, listless, anorexic, jaundice and death (Demessie and Derso,2015).

*Bovine Babesiosis* causes most serious economic losses to the livestock industry, endangering half a billion cattle across the world (Saad *et al*., 2015).The disease is of great economic importance in Nigeria due to high prevalent of ticks vector, because unlike many other parasitic conditions, it affects adults more severely than young cattle, leading to direct losses through death and the restriction of movement of animals by quarantine laws. The disease is also a barrier to improving productivity of local cattle by cross-breeding due to the high mortality of genetically superior but highly susceptible cattle, especially dairy cattle, imported from Babesia free areas. The consequence is that the quality of cattle in endemic areas remains low, therefore impeding the development of the cattle industry and the wellbeing of producers and their families (Demessie and Derso, 2015). Not many reports have been given on baseline values such as haematological and biochemical indices for Nigerian indigenous cattle breeds infected with Babesia organisms. Studies have showed that baseline values for hematological parameters differ between the various cattle breeds in the tropics (Oduye and Okunaiya, 1971). The importance of clinical presentations, haematological and biochemical indices as diagnostic and prognostic tools in natural *bovine Babesiosis* cannot be overemphasized.

Sharma *et al*., (2016) mentioned that haemoglobin (Hb), packed cell volume (PCV), differential leucocytic count (DLC), total leucocytic count (TLC) and total erythrocytic count (TEC) were significantly decreased in *bovine Babesiosis* and this might be due to the intravascular haemolysis. Alam, and Nasr, (2011) also reported a significant reduction in RBCs, HB and PCV in cattle infected with either *Babesiosis* or theileriosis. *Babesiosis* induces significant reduction in MCV, MCH and MCHC (microcytic hypochromic *anaemia*). *Bovine* infected with *Babesiosis* develop leukopenia, neutropenia and eosinopenia accompanied with lymphocytosis and monocytosis. This can be explained by the breakdown of red blood cells by Babesia sp. stimulates the phagocytic cells such as lymphocytes and monocytes to clean up the body from the toxic remnants of ruptured red blood cells (Hussein *et al*., 2007). Jackson and Lee, (2001), also reported that the significant increase in monocytes in primary Babesia infection could be attributed to their role as active mediators in the innate immune response. The aim of this study is to establish the variation in susceptibility to natural *bovine Babesiosis* among breeds, gender and ages. Also to establish the biochemical and haematological profiles in natural *bovine Babesiosis* among different breeds, gender, level of severity and ages of Nigerian cattle.

## Materials and methods.

*Source of animals and samples:*

305 cattle showing clinical signs of *Babesiosis* from some cattle farms in Oyo state, Nigeria were randomly screened for *Babesiosis* for a period of 9 months between March and December 2016. Field records for breeds, sex, age and level of severity were assessed and documented. Appropriately, 255 were negative, while 50 samples were confirmed positive for *Babesiosis* by microscopic examination of Giemsa-stained peripheral thick and thin blood smears that showed Babesia spp.

*Sampling:*

Field records for breeds, sex, age and level of severity were assessed and recorded appropriately. Breeds were established by their morphological features.Age was estimated using rostral dentition and sexes morphologically determined. Blood samples were taken from the jugular vein into sample bottles containing EDTA-K2 as anticoagulant and sample bottles without anticoagulant for the determination of hematological and biochemical indices respectively. The samples were immediately transported to the General laboratory of the Department of Veterinary Medicine, University of Ibadan, Nigeria on ice packs. Haematological analysis was performed immediately. Samples without anticoagulant were centrifuged and stored at -200c for biochemistry analysis

*Hematological examination:*

The haematological indices of the positive samples were analyzed using standard methods. Haemoglobin (Hb) concentration was determined using the cyanomethaemoglobin method. Total erythrocyte and leucocytes (RBC and WBC respectively) counts were done using an improved Neubuer haemocytometer. The packed cell volume (PCV) was determined manually using a Hawksley micro hematocrit reader (Jain, 1993). Mean Corpuscular Volume (MCV), and mean corpuscular hemoglobin concentrations (MCHC) were calculated appropriately (Jain, 1986). Thin blood smears from EDTA blood were made for manual differential cell counts with appropriate stains to calculate the absolute lymphocyte count (Lymph), absolute eosinophil count (Eos), absolute neutrophil count (Neut), and absolute monocyte count (Mono).

*Serum biochemical studies:*

The sera were analyzed for some biochemical parameters such as total protein, albumin, globulin, blood urea nitrogen, cholesterol,glucose,aspartate aminotransferase, alanine aminotransferase, alkaline phosphatase using commercial test kits supplied by Fortress Diagnostics Limited (U.K).

*Statistical analysis:*

The results for different breeds, sexes, ages and different level of severity were analyzed by one-way analysis of variance (ANOVA) to establish significant differences, followed by pair-wise comparisons using the Duncan tests. Difference were considered significant when $P < 0.05$. The computer software, SPSS version 2007 Microsoft excel for windows was used for analysis.

## Results

Variation to susceptibility among breeds of cattle showed that 32 (64%) samples were found to be White Fulani breed, followed by 8 (16%) samples belongs to Sokoto Gudali, another 8 (16%) samples belongs to Red Bororo and finally 2 (4%) samples belongs to Kuri breed. Variation to susceptibility among sexes revealed 43 (86%) female and 7 (14%) male. The susceptibility order in different age groups indicated 4 years and above of age having 27 (54% susceptibility) in number, followed by those of 3-3½years having 17 (34% susceptibility) and cattle within age bracket of 2-2½years having the least 6 (12% susceptibility). (Table I, II and III).

Hematological indices of various breeds with natural *Babesiosis* revealed Mean± S.D of PCV highest in White Fulani breed (28.6±8.76) and lowest in Sokoto Gudali breed (24.6±6.89). For Haemoglobin (HB) the highest values were recorded in White Fulani (9.3±2.98) and lowest in Sokoto Gudali (8.1±2.29).Red Blood Cells (RBCs) was highest in Red Bororo breed (8.1±2.76) and lowest in Kuri breed (5.1±1.33). For White Blood Cells (WBCs), Sokoto Gudali had the highest WBCs (14.5±7.07) and lowest value was seen in Red Bororo breed (12.6±6.09). Platelet values were highest in Sokoto Gudali (9.9±8.46) and lowest in Kuri breed (7.5±3.54). Mean Corpuscular Volume (MCV) was highest in Kuri (48.5±0.71) and lowest in Sokoto Gudali (28.8±12.16). Mean Corpuscular Hemoglobin (MCH) highest in Kuri (15.5±0.71) and lowest in Red Bororo (11.4±4.07).Mean Corpuscular Hemoglobin Concentration (MCHC) was highest in Kuri

**Table1:** Susceptibility to clinical *Babesiosis* among different breeds sampled at the study locations

| Breed | Frequency | Percentage |
|---|---|---|
| White Fulani | 32 | 64% |
| Sokoto Gudali | 8 | 16% |
| Red Bororo | 8 | 16% |
| Kuri | 2 | 4% |
| **Total** | **50** | **100%** |

**Table 2:** Susceptibility to clinical *Babesiosis* among sexes

| Sex | Frequency | Percentage |
|---|---|---|
| Male | 7 | 14% |
| Female | 43 | 86% |
| **Total** | **50** | **100%** |

**Table 3:** Susceptibility to clinical *Babesiosis* under different age groups

| Age (in years) | Distribution | Percentage |
|---|---|---|
| 2-2½ | 6 | 12% |
| 3-3½ | 17 | 34% |
| ≥4 | 27 | 54% |
| **Total** | **50** | **100%** |

**Table 4:** Breed and their Mean±S.D of Hematological Parameters

| Haematological Parameter | White Fulani | Sokoto Gudali | Red Bororo | Kuri | Normal Range |
|---|---|---|---|---|---|
| PCV (%) | 28.6±8.76 | 24.6±6.89 | 28.5±8.77 | 25±7.07 | 24-46 |
| Hb (gm %) | 9.3±2.98 | 8.1±2.29 | 9.1±3.00 | 8.2±2.40 | 8-15 |
| RBCs (☐10^12/L) | 7.5±2.44 | 7.8±1.59 | 8.1±2.76 | 5.1±1.33 | 5.0-10.0 |
| WBC (☐10^9/L) | 13.3±6.06 | 14.5±7.07 | 12.6±6.09 | 13.2±3.96 | - |
| PLATELET (☐10^9/L) | 8.3±2.87 | 9.9±8.46 | 8±2.83 | 7.5±3.54 | 10.0-80.0 |
| MCV (FL) | 40.2±18.22 | 28.8±12.16 | 36.6±13.31 | 48.5±0.71 | 40-60 |
| MCH (Pg) | 12.8±6.12 | 12.9±8.71 | 11.4±4.07 | 15.5±0.71 | 11-17 |
| MCHC (%) | 32.6±1.50 | 31.9±4.05 | 32±2.83 | 33±0 | 30-36 |
| LYMPHOCYTES (%) | 32.7±5.83 | 35.1±12.02 | 33.1±4.19 | 38±8.49 | 62-63 |
| NEUTROPHILS (%) | 66.3±5.83 | 62.9±15.24 | 65.9±4.19 | 61±8.49 | 15-33 |

(33±0) and lowest in Sokoto Gudali(31.9±4.05). Lymphocytes was highest in Kuri (38±8.49) and lowest in White Fulani(32.7±5.83) .Neutrophils was highest in White Fulani(66.3±5.83) and lowest in Kuri(61±8.49) .In all, White Fulani and Red Bororo appeared to have the best of the hematological parameters in natural *bovine Babesiosis*.(Table IV).

Biochemical parameters in the present study indicated the highest Mean± S.D of Total protein (5.5±1.87) in White Fulani breed while Sokoto Gudali had the lowest (4.2±1.64). White Fulani had the highest albumin values (1.3±0.20), while Sokoto Gudali had the lowest (1.2±0.07).White Fulani had the highest Globulin (4.2±1.73), while Sokoto Gudali had the lowest (3.0±1.6).Red Bororo had the

highest Cholesterol (174.4±71.23), while Kuri had the

lowest (133±12.73).Red Bororo had the highest Glucose (68±38.79), while Kuri had the lowest (41.5±16.26). Aspartate aminotransferase (AST) had the highest AST value (60.3±15.68) in White Fulani, while Kuri had the lowest (42.5±17.68). Alanine aminotransferase (ALT) was highest with (50.7±14.80) in White Fulani, while Kuri had the lowest (33.5±16.26). For Blood Urea Nitrogen (BUN),White Fulani and Red Bororo had the highest BUN value (2.1±0.58) and (2.1±0.38) respectively; while Kuri had the lowest (1.2±0.38).For Alkaline phosphatase (ALP), Red Bororo had the highest ALP value (117.5±9.13), while Sokoto Gudali had the lowest (106.4±9.62). (Table V). In all, White Fulani and Red Bororo appeared to have the best biochemical parameters in clinical *Babesiosis*.

For the hematological parameters under different levels of infection, the parameters appeared better in mild infection, whereas in severe infection most of the parameters were poor as shown in Table VI.

The highest and best parameters of biochemical indices were seen in mild infection when compared to severe infection as follows; Mean± S.D for Total protein was 5.8±1.57 for mild and 4.8±1.19 for severe. Albumin was 1.3±0.18 for mild and1.2±0.14 for severe. Globulin was 4.3±1.44 for mild and 3.6±1.14 for severe. Cholesterol was 162.1±46.28 for mild and164.1±92.50 for severe. Glucose was 61.7±21.70 for mild and 52.2±12.36 for severe. Aspartate aminotransferase (AST) was 60.6±15.20 for mild and 54.1±10.40 for severe. Alanine aminotransferase (ALT) was 51.2±14.30 for mild and 43.6±11.82 for severe. Blood Urea Nitrogen (BUN) was 1.8±0.59 for mild and 1.8±0.46 for severe. But for the Alkaline Phosphates (ALP) it was 113.3±16.16 for mild and 114.2±10.76 for severe as indicated in Table VII.

Hematological Parameters of males and females cattle revealed Mean±S.D of Parked Cell Volume (PCV) 31±5.72 for males and 27.3±8.65 for females. Hemoglobin (HB) were; 10.2±1.90 for males, and 8.9±2.93 for females. Red Blood Cells (RBCs) were; 7.6±1.59 for males, and 7.5±2.43 for females. White Blood Cells (WBCs) were; 13.5±4.98 for males, and 13.4±6.22 for females. Platelet were; 9.1±1.95 for males, and 7.9±2.84 for females. Mean Corpuscular Volume (MCV) were; 39.9±9.25 for males, and 38.0±17.22 for females. Mean Corpuscular Hemoglobin (MCH) were; 13±2.94 for males, and 12.1±5.72 for females. Mean Corpuscular Hemoglobin Concentration (MCHC) were; 33±0 for males, and 32.5±1.75 for females. Lymphocytes were; 37.3±6.31 for males, and 32.1±4.92 for females. Neutrophils were; 62.1±6.39 for males, and 67.0±4.95 for females. In general, it shows that, the male cattle possessed better hematological parameters than the female cattle in clinical *bovine Babesiosis* as seen in Table VIII.

**Table5:** Breed and their Mean±S.D of Biochemical Parameters

| Biochemical parameters | White Fulani | Sokoto Gudali | Red Bororo | Kuri | Range |
|---|---|---|---|---|---|
| Total Protein (gm%) | 5.5±1.87 | 4.2±1.64 | 5.0±1.56 | 4.4±1.48 | 6.7-7.5 |
| Albumin (gm%) | 1.3±0.20 | 1.2±0.07 | 1.3±0.19 | 1.2±0 | 2.5-3.8 |
| Globulin (gm%) | 4.2±1.63 | 3.0±1.60 | 3.7±1.40 | 3.17±1.48 | 3.0-3.5 |
| Cholesterol | 166.2±63.85 | 153.3±44.87 | 174.4±71.23 | 133±12.73 | - |
| Glucose (mg/dl) | 58.1±18.0 | 42.6±19.99 | 68±38.79 | 41.5±16.26 | 40-100 |
| AST (U/L) | 60.3±15.68 | 47.6±13.27 | 59.8±10.61 | 42.5±17.68 | 60-125 |
| ALT (U/L) | 50.7±14.80 | 39.5±12.76 | 50.1±12.31 | 33.5±16.26 | 4-11 |
| BUN (mg/dl) | 2.1±0.58 | 1.5±0.49 | 2.1±0.38 | 1.2±0.38 | 10-25 |
| ALP (U/L) | 117.1±22.42 | 106.4±9.62 | 117.5±9.13 | 108±22.63 | 10-77 |

**Table 6:** Mean±S.D of hematological parameters under different levels of infection (mild, moderate, severe).

| Hematological parameters | Mild | Moderate | Severe | Range |
|---|---|---|---|---|
| PCV (%) | 33.1±5.16 | 26.9±8.80 | 25.9±8.50 | 24-46 |
| Hb (gm %) | 10.9±1.72 | 8.7±2.93 | 8.4±2.91 | 8-15 |
| RBC (□10^12/L) | 7.9±1.66 | 7.5±2.37 | 7.6±2.74 | 5.0-10.0 |
| WBC (□10^9/L) | 14.5±5.26 | 13.2±5.84 | 12.8±7.26 | - |
| PLATELET (□10^9/L) | 10±1.41 | 7.7±2.73 | 7.7±2.96 | 10.0-80.0 |
| MCV (FL) | 43.2±7.92 | 36.9±11.64 | 39.3±27.35 | 40-60 |
| MCH (Pg) | 13.7±2.92 | 11.24±4.08 | 12.6±9.06 | 11-17 |
| MCHC (%) | 33±0 | 32.34±2.06 | 32.7±0.89 | 30-36 |
| LYMPHOCYTES (%) | 36±0.8 | 32.7±4.96 | 30.8±5.49 | 62-63 |
| NEUTROPHILS (%) | 63±6.08 | 66.3±4.96 | 68.3±5.59 | 15-33 |

**Table7.** Mean±S.D of biochemical parameters under different levels of infection (mild, moderate, severe).

| Biochemical parameters | Mild | Moderate | Severe | Range |
|---|---|---|---|---|
| Total Protein (gm%) | 5.8±1.57 | 5.2±2.05 | 4.8±1.19 | 6.7-7.5 |
| Albumin (gm%) | 1.3±0.18 | 1.3±0.19 | 1.2±0.14 | 2.5-3.8 |
| Globulin (gm%) | 4.3±1.44 | 3.9±1.93 | 3.6±1.14 | 3.0-3.5 |
| Cholesterol | 162.1±46.28 | 164.1±49.54 | 164.1±92.50 | - |
| Glucose (mg/dl) | 61.7±21.70 | 56.9±28.78 | 52.2±12.36 | 40-100 |
| AST (U/L) | 60.6±15.20 | 58±17.10 | 54.1±10.40 | 60-125 |
| ALT (U/L) | 51.2±14.30 | 49.1±15.86 | 43.6±11.82 | 4-11 |
| BUN (mg/dl) | 1.8±0.59 | 1.9±0.56 | 1.8±0.46 | 10-25 |
| ALP (U/L) | 113.3±16.16 | 109.1±17.42 | 114.2±10.76 | 10-77 |

**Table 8:** Mean±S.D of Hematological Parameters in *bovine Babesiosis* of male and female cattle.

| Haematological parameters | Male | Female | Range |
|---|---|---|---|
| PCV (%) | 31±5.72 | 27.3±8.65 | 24-46 |
| Hb (gm %) | 10.2±1.90 | 8.9±2.93 | 8-15 |
| RBC (□10^12/L) | 7.6±1.59 | 7.5±2.43 | 5.0-10.0 |
| WBC (□10^9/L) | 13.5±4.98 | 13.4±6.22 | - |
| PLATELET (□10^9/L) | 9.1±1.95 | 7.9±2.84 | 10.0-80.0 |
| MCV (FL) | 39.9±9.25 | 38.0±17.22 | 40-60 |
| MCH (Pg) | 13±2.94 | 12.1±5.72 | 11-17 |
| MCHC (%) | 33±0 | 32.5±1.75 | 30-36 |
| LYMPHOCYTES (%) | 37.3±6.31 | 32.1±4.92 | 62-63 |
| NEUTROPHILS (%) | 62.1±6.39 | 67.0±4.95 | 15-33 |

**Table 9:** Mean±S.D of Biochemical Parameters in *bovine Babesiosis* of male and female cattle.

| Biochemical parameters | Male | Female | Range |
|---|---|---|---|
| Total Protein (gm%) | 5.1±2.04 | 5.2±1.79 | 6.7-7.5 |
| Albumin (gm%) | 1.2±0.21 | 1.3±0.18 | 2.5-3.8 |
| Globulin (gm%) | 3.7±1.76 | 3.9±1.68 | 3.0-3.5 |
| Cholesterol | 149.3±26.63 | 166.9±64.14 | - |
| Glucose (mg/dl) | 51.4±23.66 | 57.4±24.65 | 40-100 |
| AST (U/L) | 59.6±15.15 | 57.5±15.32 | 60-125 |
| ALT (U/L) | 49.1±14.12 | 48.0±14.87 | 4-11 |
| BUN (mg/dl) | 1.8±0.55 | 1.9±0.57 | 10-25 |
| ALP (U/L) | 112.1±14.54 | 111.2±16.16 | 10-77 |

**Table10:** Mean±S.D of Hematological Parameters in *bovine Babesiosis* under different Age group

| Haematological Parameters | 2-2½years | 3-3½years | ≥4years | Range |
|---|---|---|---|---|
| PCV (%) | 26.6±9.81 | 29.2±7.76 | 27.6±9.04 | 24-46 |
| HB (g/dL) | 8.3±3.28 | 9.4±2.72 | 9.2±3.00 | 8-15 |
| RBC (□10^12/L) | 7.1±2.27 | 7.6±2.52 | 9.7±10.68 | 5.0-10.0 |
| WBC (□10^9/L) | 14.8±5.23 | 11.5±4.49 | 14.5±6.81 | |
| PLATELET (□10^9/L) | 7.4±3.29 | 8.4±2.24 | 8.2±2.79 | 10.0-80.0 |
| MCV (fL) | 39.2±16.36 | 42.3±22.29 | 36.5±12.71 | 40-60 |
| MCH (pg) | 11.8±5.02 | 13.5±7.41 | 11.8±4.33 | 11-17 |
| MCHC (%) | 29.2±4.82 | 32.3±2.02 | 32.9±0.26 | 30-36 |
| LYMPHOCYTES (%) | 30.8±2.28 | 33.2±6.00 | 33.0±5.32 | 62-63 |
| NEUTROPHILS (%) | 68.2±2.28 | 65.8±6.00 | 65.9±5.38 | 15-33 |

**Table 11:** Mean±S.D of Biochemical Parameters in *bovine Babesiosis* under different Age group

| Biochemical Parameters | 2-2½years | 3-3½years | ≥4years | Range |
|---|---|---|---|---|
| Total Protein (gm%) | 4.5±1.64 | 5.5±2.11 | 5.1±1.64 | 6.7-7.5 |
| Albumin (gm%) | 1.2±0.05 | 1.3±0.22 | 1.3±0.17 | 2.5-3.8 |
| Globulin (gm%) | 3.4±1.62 | 4.2±1.91 | 3.8±1.55 | 3.0-3.5 |
| Cholesterol | 147.5±12.39 | 178.6±83.52 | 158.67±48.69 | - |
| Glucose (mg/dl) | 49.3±20.85 | 56.9±20.31 | 58.0±27.71 | 40-100 |
| AST (U/L) | 54±11.01 | 61.1±17.15 | 56.1±14.86 | 60-125 |
| ALT (U/L) | 43.8±12.11 | 50.8±14.77 | 47.3±15.24 | 4-11 |
| BUN (mg/dl) | 1.8±0.50 | 1.9±0.52 | 1.8±0.56 | 10-25 |
| ALP (U/L) | 110.3±16.61 | 112.6±18.49 | 109.6±17.20 | 10-77 |

Biochemical Parameters in bull and cow revealed Mean±S.D of parameters as follow; Total Protein were; 5.1±2.04 for males, and 5.2±1.79 for females. Albumin were; 1.2±0.21 for males, and 1.3±0.18 for females.Globulin were; 3.7±1.76 for males, and 3.9±1.68 for females.

Cholesterol were; 149.3±26.63 for males, and 166.9±64.14 for females. Glucose were; 51.4±23.66 for males, and 57.4±24.65 for female. Aspartate aminotransferase (AST) were; 59.6±15.15 for males, and 57.5±15.32 for females. Alanine aminotransferase (ALT) were; 49.1±14.12 for male, and 48.0±14.87 for females. Blood Urea Nitrogen (BUN) were; 1.8±0.55 for males, and 1.9±0.57 for females. Alkaline Phosphatase (ALP) were; 112.1±14.54 for males, and 111.2±16.16 for females.

In all, the biochemical parameters of cow appeared better than that of bull in clinical *bovine Babesiosis* as indicated in Table IX.

Hematological features in cattle of different ages in natural *bovine Babesiosis* showed as follows; Parked Cell Volume (PCV) was; 26.6±9.81 for 2-2½years age group, 29.2±7.76 for 3-3½years age group, and 27.6±9.04 for 4years and above. Hemoglobin (HB) was; 8.3±3.28 for 2-2½years age group, 9.4±2.72 for 3-3½years age group, and 9.2±3.00 for 4years and above. Red Blood Cells (RBCs) were; 7.1±2.27 for 2-2½years age group, 7.6±2.52 for 3-3½years age group, and 9.7±10.68 for 4years and above. White Blood Cells (WBCs) were; 14.8±5.23 for 2-2½years age group, 11.5±4.49 for 3-3½years age group, and 14.5±6.81 for 4years and above. Platelets were; 7.4±3.27 for 2-2½ years age group, 8.4±2.24 for 3-3½ years age group, and8.2±2.79 for 4 years and above. Mean Corpuscular Volume (MCV) were; 39.2±16.36 for 2-2½ years age group, 42.3±22.29 for 3-3½ years age group, and 36.5±12.71 for 4years and above. Mean Corpuscular Hemoglobin (MCH) were; 11.8±5.02 for 2-2½ years age group, 13.5±7.41 for 3-3½years age group, 11.8±4.33 for 4years and above. Mean Corpuscular Hemoglobin Concentration (MCHC) were; 29.2±4.82 for 2-2½years age group, 32.3±2.02 for 3-3½years age group, and 32.9±0.26 for 4years and above. Lymphocytes were; 30.8±2.28 for 2-2½years age group, 33.2±6.00 for 3-3½years age group, and 33.0±5.32 for 4years and above.

Neutrophils were; 68.2±2.28 for 2-2½years age group, 65.8±6.00 for 3-3½years age group, and 65.9±5.38 for 4years and above. In general the features of older animals appeared better, when compared to that of young animals as seen in Table X.

The biochemical profile under different ages indicated as follows;Total Protein were; 4.5±1.64 for 2-2½years, 5.5±2.11 for 3-3½years, and 5.1±1.64 for 4years and above. Albumin were; 1.2±0.05 for 2-2½years, 1.3±0.22 for 3-3½years, and 1.3±0.17 for 4years and above. Globulin were; 3.4±1.62 for 2-2½years, 4.2±1.91 for 3-3½years, and 3.8±1.55 for 4years and above.

Cholesterol were; 147.5±12.39 for 2-2½years, 178.6±83.52 for 3-3½years, and 158.67±48.69 for 4years and above. Glucose were; 49.3±20.85 for 2-2½ years, 56.9±20.31 for 3-3½ years, and 58.0±27.71 for 4 years and above. Aspartate aminotransferase (AST) were; 54.0±11.01 for 2-2½years, 61.1±17.15 for 3-3½years, and 56.1±14.86 for 4 years and above. Alanine aminotransferase (ALT) were; 43.8±12.11 for 2-2½years, 50.8±14.77 for 3-3½years, and 47.3±15.24 for 4 years and above. Blood Urea Nitrogen (BUN) were; 1.8±0.50 for 2-2½ years, 1.9±0.52 for 3-3½ years, and 1.8±0.56 for 4 years and above. Alkaline Phosphatase (ALP) were; 110.3±16.61 for 2-2½ years, 112.6±18.49 for 3-3½ years, and 109.6±17.20 for 4 years and above.

This also revealed that parameters of 3-3½ years age group is the best, followed by that of 4years and above, while the lowest parameters observed in 2-2½ years age group Table XI.

In all, hematological parameters appeared better in mild infection compared to moderate and in severe form of *bovine Babesiosis*.

## Discussion.

The incidence of *Babesiosis* was highest in White Fulani breed of cattle. This may

probably be due to the fact that White Fulani breed were the most predominant breed in Nigeria. Kuri breed was the breed with the least incidence of *Babesiosis*.This is in agreement with the reports of (Daodu *et al*., 2009; Akande *et al*., 2011) who have earlier reported White Fulani to be the most predominant indigenous breed of cattle in Nigeria.The higher incidence of *Babesiosis* observed in cow when compared to bull, may be due to the fact that there were generally more female than male in Nigeria cattle population. This finding corroborates with (Paul *et al*., 2016) who reported higher prevalence of hemoparasites in females than in males from their study in Maiduguri, Nigeria. Kamani et.al., (2010) also discovered a similar trend and attributed their finding to the fact that female animals were generally herded much longer for the purpose of breeding and milk production, thereby prolonging their exposure to challenges of disease. This is also similar to the reports of (Asmaa *et al*., 2014; Rony *et al*., 2010 and Sarkar, 2010) where they reported higher prevalence of ectoparasitic infestations in female than the male cattle. Observation of more natural *Babesiosis* in older animals when compared to young animals as seen in this present study may be due to passive immunity received by the young animals from their Dam via colostrum, which would have been previously exposed to *Babesiosis* (Demessie and Derso, 2015). This agree with (Rony *et al*., 2010) where they reported higher ticks infestation in older animals than calves. Whereas our finding disagree with the observation of (Manan *et al*., 2007), who found that resistance increases with increase in age and that the older animals became more resistant and adaptable than young animals irrespective of the species. (Islam *et al*., 2009) in similar situation found that calves were more susceptible to tick infestation than the older animals. The severity of the clinical *Babesiosis* shows more severity in older animals than in young animals, this is similar to the earlier reports of (Mohamed and Ebied, 2014) where they reported higher severity in older animals. The mild anemia observed in this study may be attributed to the effects of haemoparasites on blood cells.This finding agrees with (Kamani *et al*.,2010) who reported that infection with Babesia, Anaplasma, Theileria and Trypanosoma species, either singly or in combination caused a significant reduction in mean PCV of cattle. It has also been reported that infection with most haemoparasites leads to destruction of erythrocytes and anemia. Hussein *et al*.,(2007) reported similar findings in cattle with *Babesiosis*. The lymphopenia and *neutrophilia* observed is in agreement with the findings of (Aulakh *et al*., 2005).This may be due to stress-induced endogenous release of corticosteroid, resulting in apoptosis of lymphocytes and increases circulating time of neutrophils due to decreased adherence to endothelium. This disagrees with (Alam and Nasr, 2011) who reported lymphocytosis and neutropenia in *bovine Babesiosis*. Hypoproteinemia and Hypoalbuminemia observed in this study may be as a result of toxic effect of Babesia spp on the hepatocytes. This is similar to the reports of (Hussein *et al*., 2007 and Yeruham *et al*., 2003) who reported hypoproteinemia and hypoalbuminemia in cattle infected with *Babesiosis*. The slight hyperglobulinemia observed in White Fulani and Red Bororo is indicative of immune response against Babesia spp, this corroborates the findings of (Hussein *et al*., 2007) who reported increase in globulin in cattle with *Babesiosis*. This is in contrast with (Alam and Nasr, 2011) who reported decrease in serum globulin. Among others, Red Bororo had the best glucose profile of 68mg/dl in *bovine Babesiosis*. There were increase serum level of liver enzymes, ALP and ALT, and a decrease in AST (except in White Fulani where AST was found to be normal) although there were no significant difference among the breeds sampled. The increase in ALP and ALT seen could also be attributed to damage effect of toxic metabolites of Babesia spp in the hepatocytes. This corroborates the findings of (Hussein *et al*.,2007), who reported increase serum level of the liver enzymes in *bovine Babesiosis*, while the decrease in AST seen could be attributed to a reduced exercise caused by a bodily discomfort, because AST is considered to be marker of great physical activity. This

supports (Tehrani *et al*., 2013) positions who reported decrease in AST in cattle naturally infected with Theileria annulata.

This disagrees with (Sharma *et al*., 2016) who reported increase in all the liver enzymes. There was significant decrease in the levels of Blood urea nitrogen in all the breeds sampled. This could be attributed to smaller high quality protein intake in which all the ingested protein is used for protein synthesis. This is also coupled with the fact that there was reduction in total protein. Tehrani *et al*.,(2013) reported similar finding in cattle naturally infected with Theileria annulata.This disagrees with (Sharma *et al*., 2014) who reported apparent increase in BUN level, although in subclinical *Babesiosis* in dairy cattle.

White Fulani breed of cattle was found with the best hematological and biochemical profiles among the four breeds. In all, animals in the age group 3-3½yrs was found to have the best hematological parameters in clinical *bovine Babesiosis*

Among the cattle sampled, the bull had better hematological parameters. This might be due to the fact that male animals generally have better hematological parameters than the female animals outside infection. This is in agreement with (Sripad *et al*., 2014) who reported higher values of the major hematological parameters (PCV, HB, PLT, Total erythrocytes Count) in male than in female cattle.

Whereas, the cow possessed an improve biochemical values than the bull. This could be attributed to improved nutritional status or hormonal interference in female animals. This supports the reports of (Al-Fartosi *et al*., 2010) who reported decrease in glucose level in male cattle than in female cattle in *Babesiosis*.

## Conclusion

The study revealed that White Fulani breed of cattle was more affected with *bovine Babesiosis* among the four local breed studied. The female are infected more than the male .The study also revealed that White Fulani, though mostly infected is the breed with the best hematological and biochemical parameters in clinical *bovine Babesiosis*. It can also be concluded that animals with mild *bovine Babesiosis* infection have best hematological and biochemical parameters. This affirms that cattle with mild *Babesiosis* infection would have a better prognosis when it comes to veterinary intervention so therefore early intervention is advised. Further study should be conducted to determine the roles of cholesterol in the pathogenesis of *bovine Babesiosis* as high cholesterol seems associated with *bovine Babesiosis* as seen in this study.

*Anaemia*, hypoglyceimia, hypoproteinemia and hypercholesteremia should be considered in the treatment and management protocol for *bovine Babesiosis*.

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# EFFECT OF VARYING DIETARY ENERGY AND PROTEIN LEVELS ON PERFORMANCE OF GROWER FUNAAB – ALPHA CHICKENS

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## Abstract

A total of 120 ten weeks old grower FUNAAB – alpha chickens were randomly allotted to four treatments replicated three times in a completely randomized block design. Each replicate consisted of two cocks and eight hens. The birds were fed a standard exotic grower diet (2650 Kcal/kg, 14%CP, Control), high energy low protein (2800Kcal/kg, 12%CP, HELP), high energy high protein (2800Kcal/kg, 16%CP, HEHP) and low energy low protein (2500Kcal/kg, 16%CP, LEHP) diets for twelve weeks. Average age and bodyweight at first egg were also recorded for each group. All data collected were subjected to analysis of variance. Dietary treatment significantly ($P<0.05$) affected average body weights of cocks at 22 weeks of age but had no effect on those of hens. Significant difference was observed in daily feed intake. Daily energy and protein intakes were significantly influenced ($P<0.01$) by treatment. Daily energy intake ranged from 193.50 to 236.47 Kcal/Kg with the LEHP group exhibiting the lowest intake. Birds in the HEHP and LEHP groups sustained the highest ($P<0.001$) feed conversion ratio (FCR) while HELP had the lowest. Age at first egg were significantly ($P<0.05$) lower in the birds fed HEHP and control while bodyweight at first egg were similar. It was concluded that feeding FUNAAB – alpha chickens with grower diet containing as low as 2500kcal energy and 14-16%CP will sustain good growth performance while lowering age at first egg.

**Key words:** Grower chickens, nutrition, reproduction

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## Introduction

Poultry commonly reared in Nigeria are chickens, ducks, turkeys, pigeons and more recently ostriches and quails. Those that are of commercial importance are chickens, guinea fowls, quails and turkeys (Sonaiya and Swan, 2004). Although there is no accurate statistics about poultry population in Nigeria, Adene and Oguntade (2006) reported a population of 137,678,943 chickens in 2003 comprising of 115,880,864 or 84% local and 21,798,079 or 16% as exotics. They further reported that 3.8 million chickens were either slaughtered or sold in 2005 alone. Raji and Toye (2014) also observed that 80% of chickens raised were the local ones. However, the production of local chickens in Nigeria has been retarded due to inadequate feeds, high mortalities, lack of adequate information on reproduction, management and nutrition (Ikanni and Annatte, 2000).

Appropriate nutrition is essential for adequate productivity in animals. Diet plays a pivotal role in maintaining growth, health and reproduction. Among the many dietary factors, protein and energy have special importance in maintaining growth and reproduction in poultry (NRC, 1994; Summers, 2008). Protein and energy-yielding feed substances therefore are the most important and yet the most expensive nutrient sources for poultry (Summers, 2008). They are usually selected as the starting ingredients in poultry diet formulations (NRC, 1994).

Furthermore in Nigeria efforts have been geared towards the development of indigenous chicken breeds with improved meat and egg production. These efforts have led to the development of the Shika brown layers by National Animal Production Institute (NAPRI) (Ikanni and Annatte, 2000). Similarly, the Federal University of Agriculture Abeokuta (FUNAAB) has developed the FUNAAB – alpha (Adebambo, 2015). However, there is little information on the nutritional requirements of these strains as it affects growth and sexual maturity. A full understanding of protein and energy metabolism is essential for all poultry classes and is fundamental for diet formulation and profitable production. The objective of this study was to evaluate the effects of varying dietary energy and protein levels on growth performance and sexual maturity of the FUNAAB - alpha Nigerian local chickens.

## Materials and Methods

The experiment was conducted at the Abubakar Tafawa Balewa University Bauchi, Bauchi state, Nigeria. Bauchi State is located between latitudes 9° 3° and 12° 3° north, longitudes 8°50' and 11° east of the equator, at an elevation of 537 meters above sea level. The land area is 49,119 km² representing 5.3% of Nigeria's total land mass. The society is primarily agrarian contributing 75% to the State's economy. The climate is characterized by two well defined seasons: The rainy season (May to October) and the dry season (November to April). The mean annual rainfall and temperature range are 905.33 mm 11 – 41°C but rainfalls are between 700 and 1250 mm in the north and south – south west zones of the state respectively (Anonymous 2011).

A total of 120 day old FUNAAB – alpha chickens were brooded together and fed a commercial chick mash (20% CP). At ten weeks of age, the growers were randomly allotted to four treatments replicated three times in a completely randomized block design (with three blocks). Each replicate consisted of two cocks and eight hens. Four experimental diets (Table 1) were prepared using locally available feed materials and as fed follows; Standard diet for exotic grower (Control), high energy, low protein (HELP), high energy, high protein (HEHP) and low energy, high protein (LEHP). All diets were provided in mash form. The diets and water were given ad libitum throughout the twelve weeks experimental period.

A pre-weighed diet was fed each morning and left-over of each day was weighed in the morning. The difference between the amount fed and the left-over represented the feed intake for the day. Average feed consumption in a group was obtained by dividing the weight of feed consumed in the

group by the number of birds in it. Each bird was weighed at the beginning of the experiment and weekly thereafter and weight gain was the difference between two consecutive weighing. Feed conversion ratio (FCR) was calculated as feed intake divided by weight gain. Average age and bodyweight at first egg were also recorded for each group.

Analysis of variance was carried out on all data collected using the general linear model of SPSS 20.0 (2011). Where means differed, Duncan multiple range test (DMRT) was used to separate them (Duncan, 1955).

## Results

Table 2 shows the results of the effects of varying dietary energy and protein levels on the productive performance of grower FUNAAB- alpha chickens. The initial weight ranges were 1062.50 – 1217.80g and 674.71–739.17g for cocks and hens respectively but were not significantly different (P>0.05) within sex. Dietary treatment however significantly (P<0.05) affected average body weights of cocks at 22 weeks of age but had no effect (P>0.05) on those of hens. Cocks on LEHP were heavier than those on HELP but had similar weight with those on control and HEHP diet. Body weight gain for both cocks and hens were statistically (P<0.05) influenced by diet at the grower phase with the HELP group exhibiting the lowest gains.

Significant difference (P<0.05) was observed in daily feed intake. Birds on control and HELP consumed more than those on the other diets. Daily energy and protein intakes were significantly influenced (P<0.01) by treatment. Daily energy intake ranged from 193.50 to 236.47 Kcal/Kg with the LEHP group exhibiting the lowest intake. Birds in the HELP group however had the least protein intake. Feed conversion ratios were 5.17, 6.36, 4.23 and 3.93 for control, HELP, HEHP and LEHP respectively. Birds in the HEHP and LEHP groups sustained the highest (P<0.001) FCR while HELP had the lowest.

The effects of grower diets on age and body weight at sexual maturity are shown in Table 3. There was a significant (P<0.05) influence of grower diet on age at first egg. Age in days were significantly (P<0.05) lower in the birds fed HEHP and control while the HELP group had the highest value (148days). Values of bodyweight at first egg for control, HELP, HEHP and LEHP were similar.

## Discussion

Several studies have investigated the effect of dietary energy and protein on performance of poultry (Joseph *et al*., 2000; Gunawardana *et al*., 2008, 2009; van Emous *et al*., 2015a, b). Dietary energy and protein had no influence on body weight of hens at 22 weeks of age contrary to that of cocks. This might have been because the hens at 22 weeks had attained mature body weight. They have to attain a threshold weight to start laying (Hafez and Hafez, 2008). The high energy low protein diet resulted in the lowest body weight and body weight gain in both cocks and hen. This might have been due to the low daily protein intake. The higher weight with increased dietary protein and energy is consistent with previous observations (Kingori *et al*., 2003; Sunder *et al*., 2007; Liu *et al*., 2015). The statistical similarity observed in body weight of hens confirms the report of Alli and Ayorinde (2013) that dietary energy and protein had no effect on hen body weight. Summers and Leeson (1993) also, did not observe improvement in body weight of pullets at 20 week of age due to increased protein and energy in the diet from 16 to 20 weeks of age.

Feed intake was lower for birds fed diets with low energy-high protein (LEHP) and high energy-high protein (HEHP). The high fibre in the LEHP diet as a result of replacing maize with wheat offal in the diet might have affected the voluntary feed intake of the birds. Average daily energy intake was also lowest for the LEHP group while average daily protein intake was lowest in the HELP group. In a similar observation, Dairo *et al*. (2010) reported that broiler chickens fed a low energy high protein diet had lowered feed intake. They also stated that the high fibre level of the diet might have

**Table 1:** Ingredients and percentage composition of different energy and protein diets fed to grower chickens

| Ingredients | Control | HELP | HEHP | LEHP |
|---|---|---|---|---|
| Maize | 60.47 | 69.94 | 63.24 | 51.00 |
| Soya bean meal | 10.60 | 5.79 | 18.30 | 15.41 |
| Wheat bran | 25.33 | 20.67 | 14.85 | 29.99 |
| Bone meal | 1.75 | 1.75 | 1.75 | 1.75 |
| Limestone | 1.25 | 1.25 | 1.25 | 1.25 |
| Salt | 0.35 | 0.35 | 0.35 | 0.35 |
| Premix* | 0.25 | 0.25 | 0.25 | 0.25 |
| Total | 100.00 | 100.00 | 100.00 | 100.00 |
| **Calculated Analysis** | | | | |
| ME (Kcal/Kg) | 2650.00 | 2800.00 | 2800.00 | 2500.00 |
| Crude Protein (%) | 14.00 | 12.00 | 16.00 | 16.00 |
| Calcium (%) | 1.02 | 1.00 | 1.02 | 1.03 |
| Phosphorus (%) | 0.59 | 0.52 | 0.53 | 0.65 |
| **Proximate composition** | | | | |
| Dry matter (%) | 92.31 | 93.49 | 91.90 | 89.41 |
| Crude protein (%) | 14.14 | 12.11 | 16.23 | 16.12 |
| Ether extract (%) | 2.08 | 3.98 | 4.51 | 2.01 |
| Crude fibre (%) | 6.56 | 5.53 | 4.48 | 8.51 |
| Ash (%) | 7.84 | 8.58 | 10.87 | 8.50 |
| NFE (%) | 61.69 | 62.29 | 55.81 | 54.27 |

*HELP – High energy low protein, HEHP – High energy high protein, LEHP – Low energy High protein*
*NFE – Nitrogen free extract, ME – Metabolizable energy*
**Each 2.5kg Optimix vitamin/mineral premix contains;Vitamin A – 8,000,000 I.U,Vitamin D3 – 1,700,000 I.U,Vitamin E – 5,000 mg,Vitamin K3 – 1,500mg, Folic Acid – 200mg, Niacin – 15,000mg, Calpan – 5,000mg,Vitamin B2 – 3,000mg,Vitamin B12 – 5mg,Vitamin B1 – 1,000mg, Vitamin B6 – 1,000mg, Biotin – 20mg, Antioxidant – 125,000mg, Cobalt – 100mg, Selenium – 100mg, Iodine – 1,000mg, Iron – 25,000mg, Manganese – 45,000mg, Copper – 3,000mg, Zinc -35,000mg, Choline Chloride – 100,000mg.*

**Table 2:** Effects of varying Dietary Energy and Protein on Growth Performance of FUNAAB – alpha Chickens

| Parameter | Control | HELP | HEHP | LEHP | ± SEM |
|---|---|---|---|---|---|
| Initial Weight Cock (g/bird) | 1217.80 | 1062.50 | 1014.50 | 1066.50 | 149.45NS |
| Initial Weight Hens (g/bird) | 739.17 | 689.83 | 734.75 | 674.71 | 74.84NS |
| Body Weight Cocks at 22 week (g) | $2683.30^{ab}$ | $2098.90^{b}$ | $2716.50^{ab}$ | $2866.50^{a}$ | 333.12* |
| Body Weight Hens at 22 weeks (g) | 1763.80 | 1475.00 | 1729.30 | 1721.30 | 56.99NS |
| Body Weight Gain Cock (g) | $1465.50^{ab}$ | $1056.70^{b}$ | $1683.20^{a}$ | $1752.80^{a}$ | 268.87* |
| Body Weight Gain Hen (g) | $1020.30^{a}$ | $786.00^{b}$ | $964.50^{ab}$ | $1014.30^{a}$ | 104.43* |
| Daily Feed Intake (g/bird) | $89.23^{a}$ | $84.05^{ab}$ | $76.21^{b}$ | $77.04^{b}$ | 3.58* |
| Daily Energy Intake (Kcal/kg/ bird) | $236.47^{a}$ | $235.34^{a}$ | $213.38^{ab}$ | $193.50^{b}$ | 9.72* |
| Daily Protein Intake (g/bird) | $12.49^{a}$ | $10.09^{b}$ | $12.19^{a}$ | $12.38^{a}$ | 0.49* |
| FCR | $5.18^{b}$ | $6.36^{a}$ | $4.23^{c}$ | $3.93^{c}$ | 0.29* |

*HELP- High Energy Low Protein, HEHP- High Energy High Protein, LEPH- Low Energy High Protein*
*a, b, c…. Means within the same row bearing different superscripts differ significantly (P<0.05);*
*SEM: standard error of mean; NS: Non significant (P>0.05); *: Significant (P<0.05).*

**Table 3:** Effects of Varying Dietary Energy and Protein Levels on Sexual Maturity of FUNAAB - alpha Chickens

| Parameter | Control | HELP | HEHP | LEHP | ± SEM |
|---|---|---|---|---|---|
| Age at First Egg (days) | 131.00[b] | 148.00[a] | 129.00[b] | 139.00[ab] | 6.27* |
| Body Weight at First Egg (g) | 1623.30 | 1296.50 | 1473.30 | 1538.60 | 105.42NS |

*HELP- High Energy Low Protein, HEHP- High Energy High Protein, LEPH- Low Energy High Protein*
*a, b, c…. Means within the same row bearing different superscripts differ significantly (P<0.05); SEM: standard error of mean; NS: Non significant (P>0.05); *: Significant (P<0.05).*

affected voluntary intake as a result compacting the gut. Uddin *et al*. (1992) reported decreased feed intake with increased dietary protein and protein and energy combination in starcross layers. Kingori *et al*. (2003) however, observed an increase in feed intake with increasing protein level between 100 – 140g/ Kg after which it plateaued. It is also a known fact that chickens consume to satisfy dietary energy requirement (Olomu, 2011) which may account for the lower protein intake in the HELP group. The feed intake (g/bird) recorded in this experiment were similar to those (73 – 83g/bird/day) recorded by Kingori *et al*. (2010) for growing local Kenyan chickens fed varying protein levels.

Feed conversion ratio was best in the low energy high protein and high protein high energy combination followed by that of the standard diet. This is a reflection of the lower feed intake in the groups and also an indication that the higher the protein contents of the diet the better the feed utilization. This agrees with the assertion of Babiker (2010) that increasing the dietary protein levels (15 and 17% CP) during the grower phase (22 – 36wks) significantly improve the feed conversion as compared to pullets fed low protein level (13% CP). A similar observation was made by Kingori *et al*. (2010) that higher crude protein in the diet of indigenous chickens supported better feed utilization. Mbajiorgu *et al*. (2011) made similar observations in indigenous Venda chickens fed varying dietary energy to protein ratio.

Age at first egg was influenced by dietary treatment with HELP birds coming into lay at an older age (148 days). The lower age at first egg of the groups (HEHP, control and LEHP) may be an indication that birds in the high protein group attained the threshold body weight required to initiate egg production very early. This is similar to the observation of El Zubeir and Mohammed (1993), that the age of birds at the point of lay decreased by increasing dietary protein level. Alli and Ayorinde (2013) demonstrated that age at first egg was influenced by protein and not energy level of the diet. Keshavarz (1998) also reported that age at first egg was not influenced by energy level used during the growing period. On the contrary, Nahashon *et al*. (2007) did not find any difference in age at first egg of guinea fowl pullets fed varying levels of energy (3000, 2900 and 2800Kcal/Kg) and protein (16,17 and 18% CP). The observation in this study that body weight of hens at first egg was not influenced by dietary treatment confirms the earlier reports of Joseph *et al*. (2000) and Alli and Ayorinde (2013) that dietary energy and protein intake had no effect on body weight at first egg. Leeson *et al*. (1997) stated that regardless of dietary energy level, pullets were smaller in weight and stature when the protein level was low. It is important to consider body weight as it is a reliable measure of how well a pullet develops. This is because there is a mature pullet body weight, which the bird should attain before the reproductive processes are initiated (Leeson *et al*,. 1991; Summers *et al*., 1991).

## Conclusion

It was concluded that feeding FUNAAB – alpha chickens with grower diet containing as low as 2500kcal energy and 14-16%CP will sustain good growth performance while lowering age at first egg.

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# BLOOD PROFILE OF BROILER CHICKENS ADMINISTERED AQUEOUS EXTRACT OF *AZADIRACHTA INDICA* (NEEM) AND *MANGIFERA INDICA* (MANGO) BARK IN WATER

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## Abstract

This study was undertaken for 56 days to determine the effect of the different extraction methods of Azadirachta indica (Neem) and Mangifera indica (mango) bark on the blood profile of broiler chickens. A total number of 288 commercial day old broiler chicks were used for the experiment. Three extraction methods namely; Maceration (i.e soaking in water for 72 hours), infusion (i.e soaking in hot water for 12 hrs) and decoction (i.e boiling in hot water for 2hours) were used with a control (no herbs). The birds were divided into two groups (144 each). Each group was sub divided into four (4) sub groups comprising of 36 birds each with three replicates of 12 birds. Each subgroup was administered either of the herbs obtained from the different extraction methods. Hence, the birds were arranged in a 2×4 experimental layouts comprising of 8 treatments in a Completely Randomized Design. The bark extracts were used as a substitute for antibiotics and administered in water for the birds at rate of 150ml/L Blood samples were collected on the 28th and 56th day of the study for haematological and serum biochemical indices determination. The result revealed that at the starter phase, haemoglobin was highest in birds administered Azadirachta indica while monocytes was highest in the birds administered Mangifera indica. The birds in the control group had the least blood calcium as against birds administered differently extracted herbs. Monocytes was the only haematological parameter that was significantly ($P<0.05$) affected by the interaction between herbs and extraction methods. Urea and Alanine amino transferase (AST) were the only serum biochemical indices that were significantly ($P<0.05$) affected by the interaction. Monocytes were highest amongst birds that were administered mango bark extracted by decoction and least among birds administered neem bark extracted by decoction. At the finisher phase, white blood cell (WBC) was increased in birds administered Mangifera indica (12.45×1012/L). The interaction between herbs and extraction methods had no significant effect ($P>0.05$) on all the parameters except for aspartate amino transferase and alanine amino transferase among the serum biochemical indices. Asparate amino transferase was highest in birds administered neem bark obtained by maceration (67.50U/L) and least value were noted in birds administered mango bark obtained by decoction (52.00U/L) and the control (52.00U/L) birds administered neem bark. The value of Alanine amino transferase was increased in birds that were administered neem bark extract obtained by maceration (34.50U/L) and was least in birds administered decocted (19.00U/L) neem bark. It can be concluded that most blood profile indices were not negatively affected by either of the herbs used or the extraction methods, hence any of the herbs as well as extraction methods can be adopted for use in broiler chickens as alternatives to antibiotics.

**Keywords:** Blood profile, extraction methods, herbs and antimicrobials

## Introduction

Apart from challenges associated with feeds in terms of availability and cost, disease caused by organisms (bacteria, protozoa, fungi and virus) is another major problems facing poultry farmers. Antibiotics have been used to prevent and treat some of these diseases especially those of bacterial origin in addition to their use as growth promoters in the diet of birds.

However, there is increasing demand for drug free food products owing to increased awareness of the residual effects of antibiotics in poultry meat, increasing resistance to antibiotics and cost of these synthetic products. This has led to intensive search for alternative natural gowth enhancers such as plants and their extracts.

Plant materials and Plant extracts also known as phytobiotics, are used widely in traditional systems of medicine (Savoia, 2012) and have been exploited in animal nutrition, particularly for their antimicrobial, anti-inflammatory, anti-oxidative, and anti-parasitic activities (Vondruskova *et al*., 2010; Hashemi and Davoodi, 2011). Several plants have multifunctional beneficial properties which are derived from their specific bioactive components. Biologically active constituents of plants are mostly secondary metabolites, such as terpenoids, phenolics, glycosides, and alkaloids (Huyghebaert *et al*., 2011).

Plants extract are gradually being used in developing countries, however, they are extensively used in feed as growth promoters and; prevention and control of diseases (Hashemi and Davoodi, 2011; Abreu *et al*., 2012), in Asian, African, and South American countries.

Plant extracts are generally considered safe and effective antibacteria. One such plant is neem (Azadirachta indica) that has been shown to have important medicinal properties (Biswas *et al*., 2002). The neem leaves extract have nimbin, nimbinene, 6-desacetylnimbiene, nimbandiol, nimbolide and quercetin (Mitra *et al*., 2000). This herb has different medicinal properties like antibacterial, antifungal, hepatoprotective, antiviral and antiprotozoal and has no side effects (Kale *et al*., 2003).

Mango plant as well has several biological properties such as antibacterial, antifungal and antioxidant activities. Stem bark of mango has been found to possess anti-helminthic and anti-allergic properties. Abdalla *et al*. (2007) reported that, mango seed kernel extract showed inhibitory effect against coliform and *E. coli* isolates.

Methods of extraction and preparation of the crude extracts and its purity greatly influence the quantity and quality of extract as well as inhibition activity of some herbs against infectious organisms. However there is dearth of information on influence of extracts obtained from different extraction methods on the health status of broiler chickens.

Blood analysis is an impotant tool readily available to monitor the health status of livestock. Afolabi *et al*. (2010) posited that changes in haematological parameters are often used to determine stresses due to nutrition and other factors. Hence this study was carried to investigate changes in blood profile of broiler chickens as influences by different extraction methods of Mangifera indica and Azadirachta indica

## Materials and Methods

*Experimental Site*

The experiment was carried out at the Teaching and Research Farms,Federal University of Agriculture, Abeokuta, South-west, Ogun State, Nigeria.The farm area lies within latitude 7°10"N. Longitude 3°2"E and Altitude 76mm above the sea level. It falls within the derived savannah zone of South-Western Nigeria. It has a humid climate with mean annual rainfall of 1037mm and temperature of about 34.7°C. (Google Earth, 2016).

*Source and Preparation of Experimental Plant Material*

Fresh neem and mango bark were collected from Neem and mango tree within and outside the university premises.They were air dried until they became dry.Three methods

of extraction namely: maceration, infusion and decoction were used to get extracts from neem and mango bark.

Maceration; In this process, 100g of either neem or mango bark was soaked in 1liter of cold water for 72hours (3days) after which the mixture was filtered and a dose of 150ml of the extract was added to 1liter of water and given to the birds.

Infusion; in this method of extraction, 100g of either neem or mango bark was soaked in 1liter hot water for 12hrs after which the mixture was filtered to obtain the extract to be given to the birds.

Decoction; in this method of extraction, 100g of herb (neem or mango) bark was boiled in water for 2hrs. This mixture was allowed to cool before being strained to obtain the extract.

*Source of chicks and brooding*

A total number of 288 commercial broiler day old chicks was used for this experiment and were purchased from a reputable hatchery. Prior to their arrival, the pens were cleaned and cleared of dirt and or debris. The brooding pen was washed and fumigated with fumigants and insecticides so as to prevent the invasion of predators during and after the brooding. The birds were brooded for two weeks during which heat was adequately provided and the birds were fed with balanced commercial feed ad libitum and water.

The brooding pen was covered with polythene bags so as to conserve heat however; the heat supplied was monitored so as to prevent heat stress on the birds. As the birds grew, the polythene bags were opened gradually to help the birds acclimatize. Light was supplied in the brooding house so as to help the birds feed well. The broiler chickens were raised under intensive system of management using deep litter system.

*Experimental Design and Management*

The experiment was arranged in a 2×4 factorial layout comprising of eight treatment groups. The birds were divided into two groups (144 each). Each group was sub divided into four (4) sub groups comprising of 36 birds with three replicates of 12 birds each. Each subgroup was either administered Azadirachta indica or Mangifera indica obtained from different extraction methods; maceration, infusion, decoction and control (no herbs).

The control groups were given necessary medications (antibiotics, coccidiostat and vitamins) and vaccinations (Gumboro vaccine on the 7th and 15thday and lasota at 4weeks of age). Birds that were administered either of the herbs were not vaccinated against Newcastle and were also not given antibiotics. Herbs were supplied in their water for three consecutive days in each week.

## Data Collection

*Blood Collection*

On the 28th day and 56th day, two birds were selected from each replicate for bleeding. With a 5ml syringe fitted with a 24-gauge sterile hypodermic needle, 5ml of blood was carefully drawn from the left wing at the point of bifurcation of the vein. 3m of the blood was put into a sterilized bottle containing Ethylene diamine tetraetic acid (EDTA) as anticoagulant, and shaken gently to prevent coagulation, while the rest of the blood was put into a sterilized bottle which had no anticoagulants in it for serum biochemical analysis. All blood samples were sent to the Laboratory for analysis.

*Determination of Haematological and Serum biochemical Parameters*

Haematological parameters; haemoglobin (Hb), packed cell volume (PCV), red blood cell (RBC) and white blood cell (WBC) and others such as Mean Corpuscular Haemoglobin (MCH) and Mean Corpuscular Haemoglobin Concentration (MCHC) were estimated byfollowing procedures described by Jain (1986). Mean Corpuscular Volume was estimated by calculation using a standard formula (Jamie and Howlett, 2008).

Serum total protein, albumin, globulin, glucose, cholesterol were determined spectrophotometrically (Chemito Spectrosan 2600) according to the method of Tietz (1995) as

described in Randox(R) diagnostic kit manual. Alanine and Aspartate Aminotransferase were determined spectro-photometrically according to the method of Reitman and Frankel (1970), using commercial Randox kit.

*Statistical Analysis*

Data generated was subjected to Analysis of Variance (ANOVA) in a 2 x 4 experimental layout using one way analysis of variance SAS (1999). Significant means among the variable were separated using Duncan Multiple Range Test (DMRT) as contained in the software.

## Results

Main effect of herbs and extraction methods of herbs (Mangifera indica and Azadirachta indica) on the blood profile of broiler chickens at the starter phase

The result of effect of herbs and extraction methods of herbs on the blood profile of broiler chicken at starter phase is shown in Table 1. Mango bark and Neem bark had similar (P>0.05) effect on the blood profile of broiler chickens except haemoglobin and monocytes which differs significantly (P<0.05) amongst the haematological parameters. Haemoglobin concentration of broiler birds was higher when administered Azadirachta

**Table 1:** Main effect of different extraction methods of *Mangifera indica* and *Azadirachta indica* on the blood profile of broiler chicken at starter phase.

| | Effect of herbs | | Effect of extraction methods | | | |
|---|---|---|---|---|---|---|
| **Parameters** | **M.I** | **A. I** | **Control** | **Maceration** | **Infusion** | **Decoction** |
| Haematology | | | | | | |
| Pack cell volume(%) | 37.08±1.89 | 38.05±00.78 | 38.83±1.34 | 36.50±1.28 | 37.33±1.82 | 38.5±1.54 |
| Haemoglobin (g/dl) | 11.71±0.27$^{b}$ | 12.50±0.25$^{a}$ | 12.60±0.33 | 11.55±0.35 | 12.07±0.42 | 12.20±0.46 |
| RBC (×1012/L) | 3.03±0.12 | 3.15±0.13 | 3.20±0.18 | 3.03±0.80 | 2.95±0.17 | 3.17±0.25 |
| WBC(×1012/L) | 11.61±0.46 | 11.53±0.63 | 11.07±0.51 | 10.65±0.64 | 12.67±1.08 | 11.90±0.58 |
| Heterophil (%) | 28.91±2.38 | 29.66±1.84 | 27.83±2.36 | 32.17±2.40 | 30.67±2.81 | 26.50±4.09 |
| Lymphocytes (%) | 69.08±2.16 | 68.33±1.99 | 69.17±2.76 | 66.67±2.21 | 67.50±2.99 | 71.50±3.74 |
| Eosinophil (%) | 0.75±0.18 | 0.33±0.14 | 0.17±0.17 | 0.67±0.21 | 0.83±0.17 | 0.50±0.34 |
| Basophil (%) | 0.33±0.18 | 0.33±0.14 | 0.33±0.21 | 0.17±0.17 | 0.33±0.21 | 0.50±0.34 |
| Monocytes (%) | 0.92±0.23$^{a}$ | 0.33±0.14$^{b}$ | 0.83±0.30 | 0.33±0.21 | 0.67±0.33 | 0.67±0.33 |
| Serum | | | | | | |
| Total protein (g/dl) | 4.67±0.37 | 4.67±0.57 | 4.42±1.12 | 4.48±0.47 | 4.85±0.43 | 4.92±0.59 |
| Albumin (g/dl) | 2.65±0.24 | 2.70±0.29 | 2.52±0.53 | 2.56±0.30 | 2.90±0.21 | 2.73±0.45 |
| Globulin (g/dl) | 2.01±0.14 | 1.97±0.30 | 1.90±0.60 | 1.91±0.19 | 1.95±0.24 | 2.18±0.15 |
| Cholesterol(g/dl) | 89.92±6.16 | 90.67±3.68 | 81.50±8.40 | 101.00±7.42 | 89.00±3.20 | 89.66±7.19 |
| Glucose(Mmol/L) | 128.50±2.29 | 125.33±3.08 | 121.67±3.86 | 131.83±3.63 | 128.33±2.64 | 125.83±4.60 |
| Calcium (mg/dl) | 8.55±0.47 | 8.95±0.34 | 7.67±0.56$^{b}$ | 9.83±0.27$^{a}$ | 8.85±0.44$^{ab}$ | 8.65±0.69$^{ab}$ |
| *Urea* (mg/dl) | 2.23±0.18 | 1.93±0.21 | 2.27±0.29 | 2.48±0.30 | 1.73±0.26 | 1.85±0.19 |
| AST (U/L) | 60.83±2.13 | 65.91±2.52 | 66.00±2.29 | 61.83±2.70 | 61.83±4.33 | 63.83±4.41 |
| ALT (U/L) | 28.42±1.74 | 27.67±1.61 | 30.66±2.13 | 28.66±2.18 | 26.50±2.81 | 26.33±2.26 |

*AST= Aspartate Amino Transfarase, ALT = Alamine Amino Transfarase, RBC = Red blood cell, WBC = white blood cell, M.I = Mangifera indica, A.I = Azadirachta indica*

**Table 2:** Effect of interaction between herbs and extraction methods on blood profile at starter phase

| | *Mangifera indica* | | | | *Azadirachta indica* | | | |
|---|---|---|---|---|---|---|---|---|
| **Parameters** | **Control** | **Maceration** | **Infusion** | **Decoction** | **Control** | **Maceration** | **Infusion** | **Decoction** |
| **Haematology** | | | | | | | | |
| Pack cell volume (%) | 38.67±1.86 | 36.66±2.03 | 36.33±3.84 | 36.67±2.67 | 39.00±1.73 | 36.33±2.02 | 38.33±0.88 | 40.33±1.20 |
| Haemoglobin (g/dl) | 12.53±0.47 | 11.40±0.44 | 11.46±0.67 | 11.43±0.59 | 12.67±0.55 | 11.70±0.62 | 12.67±0.26 | 12.970±0.33 |
| RBC (×1012/L) | 3.23±0.20 | 3.03±0.18 | 2.90±0.35 | 2.93±0.29 | 3.17±0.35 | 3.03±0.03 | 3.00±0.12 | 3.40±0.40 |
| WBC(×1012/L) | 11.8±0.51 | 11.10±1.22 | 12.20±1.50 | 11.33±0.43 | 10.33±0.70 | 10.20±0.58 | 13.13±1.81 | 12.45±1.07 |
| Heterophil (%) | 26.6±4.91 | 35.33±4.05 | 32.00±4.35 | 21.66±3.28 | 29.00±1.53 | 29.00±1.53 | 29.33±4.33 | 31.33±7.06 |
| Lymphocytes (%) | 71.67±4.41 | 63.67±3.84 | 65.67±3.84 | 75.33±3.28 | 66.67±3.52 | 69.67±0.88 | 69.33±5.17 | 67.67±6.69 |
| Eosinophil (%) | 0.33±0.33 | 0.66±0.33 | 1.00±0.00 | 1.00±0.58 | 0.00±0.00 | 0.67±0.33 | 0.67±0.33 | 0.00±0.00 |
| Basophil (%) | 0.33±0.33 | 0.00±0.00 | 0.67±0.67 | 0.33±0.33 | 0.33±0.33 | 0.33±0.33 | 0.33±0.33 | 0.33±0.33 |
| Monocytes (%) | 1.00±0.58$^{ab}$ | 0.33±0.33$^{ab}$ | 1±0.58$^{ab}$ | 1.33±0.33$^{a}$ | 0.67±0.33$^{ab}$ | 0.33±0.33$^{ab}$ | 0.33±0.33$^{ab}$ | 0±0$^{b}$ |
| **Serum** | | | | | | | | |
| Total protein (g/dl) | 4.20±0.56 | 4.73±0.74 | 4.77±0.77 | 4.97±1.23 | 4.63±2.43 | 4.23±0.71 | 4.93±0.57 | 4.87±0.52 |
| Albumin (g/dl) | 2.47±0.41 | 2.63±0.41 | 2.80±0.40 | 2.73±0.89 | 2.57±1.12 | 2.50±0.53 | 3.00±0.23 | 2.73±0.48 |
| Globulin (g/dl) | 1.73±0.20 | 2.10±0.35 | 1.97±0.38 | 2.23±0.33 | 2.07±1.23 | 1.73±0.17 | 1.93±0.38 | 2.13±0.03 |
| Cholesterol (g/dl) | 70.00±13.79 | 101.00±15.52 | 88.33±3.44 | 100.33±8.51 | 93.00±5.57 | 101.00±5.85 | 89.67±6.01 | 79.00±8.50 |
| Glucose (Mmol/L) | 126.33±13.79 | 130.33±5.46 | 126.00±3.16 | 131.33±3.84 | 117.00±2.31 | 133.33±5.81 | 130.66±4.05 | 120.33±7.79 |
| Calcium (mg/dl) | 7.50±1.03 | 9.67±0.48 | 9.03±0.75 | 8.00±1.32 | 7.83±0.69 | 10.00±0.32 | 8.67±0.64 | 9.30±0.47 |
| *Urea* (mg/dl) | 2.67±0.48$^{ab}$ | 2.07±0.49$^{bc}$ | 2.17±0.33$^{b}$ | 2.03±0.12$^{bc}$ | 1.87±0.18$^{abc}$ | 2.90±0.20$^{a}$ | 1.30±0.21$^{c}$ | 1.67±0.37$^{bc}$ |
| AST (U/L) | 65.00±4.62$^{ab}$ | 59.67±4.33$^{ab}$ | 53.33±2.33$^{b}$ | 65.33±2.67$^{ab}$ | 67.00±2.00$^{ab}$ | 64.00±3.61$^{ab}$ | 70.33±4.06$^{a}$ | 62.33±9.39$^{ab}$ |
| ALT (U/L) | 29.33±3.76 | 32.67±0.67 | 26.67±4.41 | 25.00±4.04 | 32.00±2.65 | 24.67±2.73 | 26.33±4.48 | 27.67±2.73 |

*PCV= Pack Cell volume, Hb= Haemoglobin, RBC= Red Blood Cell,WBC= White Blood cell, H= Heterophil, L= lymphocytes, E= Eosinophil, B= Bilirubin, M= Mesophil,TP= Total Protein, ALB= Albumin, GLOB= Globulin, CHOLEST= Cholesterol, GLUCO= Glucose, CAL= Calcium, AST= Aspartate Amino Transfarase, ALT= Alamine Amino Transfarase*

indica (12.50g/dl) than Mangifera indica (11.71g/dl). Concentration of monocytes (0.92%) was increased amongst bird administered mango bark extract compared to those that were administered neem bark extract (0.33%).

The extraction methods; maceration, infusion and decoction had no significant (P<0.05) effect on the haematological and serum biochemical indices of the broiler chicken except calcium which was significantly (P<0.05) affected. Calcium had highest value (9.83mg/dl) in birds that were administered herb extracted by maceration while the control group had the least value (7.67mg/dl) and the others had comparable values.

Effect of interaction between herbs and extraction methods on the blood profile of broiler chicken at starter phase.

Table 2 shows the interaction effect between herbs and extraction methods on the blood profile of broiler chickens at starter phase. Monocytes was the only haematological parameter that was significantly (P<0.05) affected. The serum biochemical indices were also not affected (P>0.05) except the urea and Alamine amino transfarase (AST) that were significantly (P<0.05) affected.

It was observed that Monocytes value (1.33%) was highest amongst the birds that were administered mango bark extracted by decoction and least value (0.00%) amongst the birds administered neem bark extract obtained by decoction while others had similar values. Blood urea value (2.90mg/dl) was increased in birds that were administered neem bark using maceration method of extraction and least (1.30mg/dl) in birds administered neem bark

**Table 3:** Main effect of different extraction method of *Mangifera indica* and *Azadirachta indica* on the blood profile of broiler chicken at finisher phase

| | Effect of Herbs | | Effect of Extraction | | | |
|---|---|---|---|---|---|---|
| **Parameters** | **M.I** | **A.I** | **Control** | **Maceration** | **Infusion** | **Decoction** |
| Haematology | | | | | | |
| Pack cell volume (%) | 35.00±2.96 | 34.00±3.71 | 35.25±7.29 | 35.75±3.75 | 36.5±2.25 | 30.5±5.10 |
| Haemoglobin (g/dl) | 11.61±1.03 | 11.29±1.24 | 11.70±2.44 | 12.10±1.32 | 11.88±0.84 | 10.13±1.71 |
| RBC (×1012/L) | 2.10±0.18 | 2.16±0.24 | 2.18±0.47 | 2.35±0.21 | 2.28±0.13 | 1.73±0.22 |
| WBC(×1012/L) | 12.45±0.56[a] | 10.75±0.39[b] | 12.56±1.04 | 11.25±0.81 | 11.38±0.89 | 11.20±0.46 |
| Heterophil (%) | 28.75±1.64 | 29.13±1.74 | 32.00±1.47 | 28.50±2.50 | 28.50±2.32 | 26.75±2.87 |
| Lymphocytes (%) | 68.38±1.35 | 68.63±1.64 | 65.00±1.58 | 69.50±2.32 | 69.50±1.88 | 70.00±2.04 |
| Eosinophil (%) | 0.50±0.19 | 0.25±0.16 | 0.50±0.29 | 0.25±0.25 | 0.25±0.25 | 0.50±0.29 |
| Basophil (%) | 1.00±0.27 | 0.75±0.25 | 1.00±0.41 | 0.50±0.29 | 1.00±0.41 | 1.00±0.41 |
| Monocytes (%) | 1.38±0.32 | 1.25±0.37 | 1.50±0.29 | 1.25±0.48 | 0.75±0.48 | 1.75±0.63 |
| Serum | | | | | | |
| Total protein (g/dl) | 4.45±0.55 | 4.16±0.56 | 3.95±0.49 | 4.75±0.92 | 3.85±0.56 | 4.70±1.12 |
| Albumin (g/dl) | 2.68±0.28 | 2.40±0.34 | 2.32±0.33 | 2.63±0.46 | 2.30±0.35 | 2.90±0.65 |
| Globulin (g/dl) | 1.78±0.27 | 1.76±0.27 | 1.60±0.21 | 2.13±0.48 | 1.55±0.23 | 1.80±0.54 |
| Cholesterol (g/dl) | 85.13±2.24 | 80.75±3.89 | 76.25±2.49 | 83.50±5.69 | 84.50±3.79 | 87.50±4.94 |
| Glucose (Mmol/L) | 138.25±3.28 | 143.00±6.95 | 133.75±4.69 | 151.75±6.75 | 137.50±4.80 | 139.50±11.50 |
| Calcium (mg/dl) | 7.34±0.55 | 7.68±0.67 | 7.90±0.98 | 8.22±0.99 | 6.75±0.80 | 7.15±0.69 |
| *Urea* (mg/dl) | 2.16±0.29 | 2.10±0.31 | 1.80±0.15 | 2.53±0.54 | 1.90±0.35 | 2.30±0.54 |
| AST (U/L) | 54.38±2.19 | 60.63±2.35 | 52.50±1.32 | 61.50±4.90 | 58.50±1.94 | 57.50±4.19 |
| ALT (U/L) | 24.50±2.13 | 27.75±2.48 | 24.25±1.79 | 28.00±3.80 | 26.50±3.22 | 25.75±4.76 |

*AST= Aspartate Amino Transfarase, ALT= Alamine Amino Transfarase, RBC= Red blood cell, WBC= white blood cell, M.I= Magnifera indica, A.I= Azadirachta indica*

extracted by infusion. The value of AST was highest (70.33U/L) amongst birds administered infused neem bark and least (53.33U/L) in birds administered infused mango bark in water.

Main effect of herbs and extraction methods of herbs (Mangifera indica and Azadirachta indica) on the blood profile of broiler chickens at finisher phase

The value of Alanine amino transferase level was increased (34.50U/L) in birds that were administered neem bark extract obtained by maceration and was least (19.80U/L) in bird's administered decocted neem bark.

## Discussion

The result of the effect of herbs and extraction methods of herbs on the blood profile of the broiler chickens at finisher phase is presented in Table 3. The two herbs; Mangifera indica and Azadirachta indica had similar (P>0.05) effect on the haematological parameters except theWBC which was affected significantly (P<0.05). The serum biochemical parameters were not affected significantly (P>0.05).WBC value (12.54 ×109/L) increased in broiler chickens administered mango bark extract compared to those administered neem bark extract (10.75 ×109/L).

The result showed that the extraction methods; maceration, infusion and decoction had no significant effect (P>0.05) on both the haematological and serum biochemical indices. Pack cell volume range was from between 30.5% - 36.5% and haemoglobin ranged from 10.13g/dl – 12.10g/dl. Total protein, albumin and globulin range was between 3.85g/dl-4.75g/dl, 2.30g/dl-2.90g/dl and 1.55g/dl-2.13g/dl respectively.

*Effect of the interaction between Herbs and Extraction methods on the blood profile of broiler chickens at the finisher phase*

The interaction effect between herbs and extraction methods on the blood profile of broiler chickens at the finisher phase is shown in Table 4. The interaction between the herbs and extraction methods had no significant (P<0.05) effect on all the parameters except for AST and ALT among the serum biochemical indices which were significantly affected (P>0.05). Aspartate amino transferase value was highest (67.50 U/L) in birds administered neem bark extract obtained by maceration and the least value (52.00 U/L) were noted in birds administered decocted mango bark and the control group of bird administered neem bark.

Blood act as a pathological reflector of the status of exposed animals to toxicant and other conditions (Olafedehan *et al*., 2010) and hence essential tool in the diagnosis and monitoring of diseases (Merck Manual, 2012). In this study, similar effect of herbs (Mangifera indica and Azadirachta indica) and extraction methods (maceration, infusion and decoction) on the haematological and serum biochemical parameters is an indication that blood cell formation, oxygen carrying capacity, body defense and major organs e. g. kidney and liver were not negatively affected. Pack cell volume gives an insight to the physiological states of birds in terms of blood formation and function. The PCV of the birds in this study (both starter and finisher phase) was within normal range (24.9%-45.2%) of healthy birds as reported by Mitruka and Rawsley (1977) and was similar to the range reported by Esonu *et al*. (2007).This indicates that the herbs and extraction methods used did not interfere with the birds' blood cell formation and function. Haemoglobin is known as the protein molecule in the red blood cell that transports oxygenated blood in the body. It also indicates the iron carrying capacity of the blood. In this study, the haemoglobin at starter phase was higher in birds administered neem bark which indicates that they had a better oxygen carrying capacity than that of the birds administered mango bark. The haemoglobin range in this study was within the range (7.79g/dl-10.41g/dl) reported by Ekunseitan *et al*. (2013) for broiler chickens.

The white blood cell count at both phases fell within range (9.20-28.60) reported by Mitruka and Rawsley (1981) and this is indicative that the body defense of the birds was strong against infections and diseases. However, increased WBC in birds that were administered mango bark at the finisher phase

**Table 4:** Effect of interaction between herbs and extraction methods of herbs on blood profile at finisher phase

| | *Mangifera indica* | | | | *Azadirachta indica* | | | |
|---|---|---|---|---|---|---|---|---|
| **Parameters** | **Control** | **Maceration** | **Infusion** | **Decoction** | **Control** | **Maceration** | **Infusion** | **Decoction** |
| **Haematology** | | | | | | | | |
| Pack cell volume (%) | 29.00±1.00 | 39.50±4.50 | 38.00±5.00 | 33.50±11.50 | 41.50±15.50 | 32.00±6.00 | 35.00±1.00 | 27.50±25.00 |
| Haemoglobin (g/dl) | 9.40±0.10 | 13.35±1.65 | 12.55±1.75 | 11.15±3.05 | 14.00±5.00 | 10.88±2.15 | 11.20±0.60 | 9.10±0.80 |
| RBC (×1012/L) | 1.85±0.55 | 2.60±0.20 | 2.20±0.30 | 1.75±0.45 | 2.80±1.00 | 2.10±0.30 | 2.35±0.05 | 1.70±0.30 |
| WBC(×1012/L) | 13.35±2.15 | 12.50±0.90 | 12.80±0.30 | 11.15±0.85 | 11.80±0.80 | 10.00±0.20 | 9.95±0.75 | 11.25±0.75 |
| Heterophil (%) | 30.50±1.50 | 32.00±2.00 | 29.00±4.00 | 23.50±3.50 | 33.50±3.53 | 25.00±3.00 | 28.00±4.00 | 30.00±4.00 |
| Lymphocytes (%) | 66.00±2.00 | 66.50±2.12 | 68.50±4.95 | 72.50±3.53 | 64.00±4.24 | 72.50±4.94 | 70.50±3.53 | 67.50±3.53 |
| Eosinophil (%) | 0.50±0.50 | 0.50±0.50 | 0.00±0.00 | 1.00±0.00 | 0.50±0.50 | 0.00±0.00 | 0.50±0.50 | 0±0.00 |
| Basophil (%) | 1.00±0.00 | 0.50±0.50 | 1.50±0.50 | 1.00±1.00 | 1.00±1.00 | 0.50±0.50 | 0.50±0.50 | 1.00±0.00 |
| Monocytes (%) | 2.00±0.00 | 0.50±0.50 | 1.00±1.00 | 2.00±0.00 | 1.00±0.00 | 2.00±0.00 | 0.50±0.50 | 1.50±1.50 |
| **Serum** | | | | | | | | |
| Total protein (g/dl) | 4.45±0.95 | 4.50±0.30 | 3.50±0.50 | 5.35±2.35 | 3.40±0.20 | 5.00±2.20 | 4.20±1.20 | 4.50±1.50 |
| Albumin (g/dl) | 2.70±0.50 | 2.65±0.25 | 2.20±0.30 | 3.15±1.50 | 1.95±0.35 | 2.60±1.10 | 2.40±0.80 | 2.65±1.05 |
| Globulin (g/dl) | 1.75±0.45 | 1.85±0.05 | 1.30±0.20 | 2.20±1.20 | 1.45±0.15 | 2.40±1.10 | 1.80±0.40 | 1.40±0.00 |
| Cholesterol(g/dl) | 78.00±1.00 | 92.50±5.50 | 86.00±1.00 | 84.00±1.00 | 74.50±5.50 | 74.50±1.50 | 83.00±9.00 | 91.00±11.00 |
| Glucose(Mmol/L) | 138.50±2.50 | 146.50±4.50 | 139.50±4.5 | 128.50±9.50 | 129.00±9.00 | 157.00±14.00 | 135.50±10.50 | 150.50±21.50 |
| Calcium (mg/dl) | 9.00±1.40 | 6.55±0.05 | 6.25±1.35 | 7.55±0.45 | 6.80±1.20 | 9.90±0.60 | 7.25±1.25 | 6.75±1.55 |
| *Urea* (mg/dl) | 1.85±0.25 | 2.55±0.55 | 1.65±0.25 | 2.60±1.10 | 1.75±0.25 | 2.50±1.20 | 2.15±0.75 | 2.00±0.60 |
| AST (U/L) | 53.00±1.00$^{ab}$ | 55.50±8.50$^{ab}$ | 57.00±3.00$^{ab}$ | 52.00±6.00$^{b}$ | 52.00±3.00$^{b}$ | 67.50±0.50$^{a}$ | 60.00±3.00$^{ab}$ | 63.00±3.00$^{ab}$ |
| ALT (U/L) | 22.50±3.50$^{bcd}$ | 21.50±1.50$^{cd}$ | 21.50±2.50$^{cd}$ | 32.50±4.50$^{ab}$ | 26.00±1.00$^{abcd}$ | 34.50±0.50$^{a}$ | 31.50±2.50$^{abc}$ | 19.00±5.00$^{d}$ |

*PCV= Pack Cell volume, Hb= Haemoglobin, RBC= Red Blood Cell, WBC= White Blood cell, H= Heterophil, L= lymphocytes, E= Eosinophil, B= Bilirubin, M= Mesophil, TP= Total Protein, ALB= Albumin, GLOB= Globulin, CHOLEST= Cholesterol, GLUCO= Glucose, CAL= Calcium, AST= Aspartate Amino Transfarase, ALT= Alamine Amino Transfarase*

as against those administered neem bark could probably imply that the birds are responding to challenges due to infections or stress.

Monocytes are believed to be the white blood differential that fights off viruses and fungi. They form the largest part of the white blood cell. At starter phase, though the monocyte was significant, values were within range (0.00%-1.00%) of the study carried out by Ayoola *et al.* (2015) as against the range (1.00%-2.71%) carried out by Odoh and Bratte (2015) which was a little higher in range.

Similar total protein, serum albumin and globulin in this study shows that the types of herbs and extraction methods did not interfere with dietary protein metabolism since the levels in the blood depends on the dietary protein availability and utilization (Obikaonu *et al.*, 2011)

The blood urea at starter phase was within range (1.80µ/L-2.00µ/L) reported in a study carried out by Ayoola *et al.* (2015). Significant decrease in blood urea indicates proper kidney function and effective utilization of the protein in the diet of the birds Obikaonu *et al.* (2011)

Alanine amino transfarase and Asaparate amino transfarase indicates the liver condition of the birds. In this study, AST and ALT fell within range (18.00U/L-53.33U/L and 12.00U/L-23.33U/L, respectively) reported by Obikaonu *et al.* (2011). Although the birds administered neem bark extract had increased AST, the level is still within the reference or normal value for healthy chicken.

## Conclusions

Based on this study, both the haematological and serum biochemical indices were not affected by the herbs at the starter phase except for the haemoglobin which was high in birds administered neem bark.Extraction methods of herbs only influenced calcium among other blood indices at the starter phase. Monocyte was highest in birds administered mango bark extracted by decoction while urea was increased in birds administered neem bark extracted by maceration at the starter phase.

At the finisher phase, white blood cells increased in the birds administered mango bark. Alanine amino transfarase and AST were significantly influenced by the interaction effect of herb types and extraction methods at the finisher phase.

## Impact

This study was able to assess the implication of oral administration of two herbs; Mangifera indica and Azadirachta indica bark on the health status of broiler chickens. It provides vital information about different simple extraction methods of herbs and the possible influence of the different extracts on the blood profile of broiler chickens.

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# BACTERIOLOGICAL QUALITY OF MILK PRODUCED AND MARKETED BY SMALLHOLDER DAIRY FARMERS IN MBEYA AND MBOZI DISTRICTS, TANZANIA

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## Abstract

The study was conducted to determine the extent of milk contamination along the milk market channels in Mbeya and Mbozi districts, Tanzania. The study was conducted in the wet and dry seasons and involved sampling milk from 96 randomly selected milk producing households, 18 milk collection points and 36 milk shops for bacterial load analysis. A total of 300 raw milk samples were collected from bulked herd milk, collection points and milk shops. In addition144 samples of boiled hot and soured milk were collected from milk shops for bacterial analysis. General Linear Model procedure of SAS was used to study the extent of bacterial load along the market channels. Overall mean for Total Bacteria Counts (TBC), Total Coliform Counts (TCC) and Total Staphylococcus Counts (TSC) were 5.86, 3.47, 4.79 and 5.72, 3.40, 4.25 log10 cfu/ml for Mbeya and Mbozi districts, respectively. Mean TBC and TCC were ($p<0.05$) higher in the wet than in dry seasons. Furthermore, TSC varied ($p<0.05$) between the study districts while no significant difference was observed for TBC and TCC. Raw milk collected from farmer herds had ($p<0.05$) higher TBC and TCC in the wet season compared to dry season. Moreover, raw milk collected from milk collection points and milk shops differed significantly between the seasons in terms of TBC and TCC. Soured and boiled hot milk sold in milk shops had ($p<0.05$) higher TCC counts in the wet season than in the dry season. Furthermore, TSC in soured milk was ($p<0.05$) higher in the dry season the than in the wet season in Mbozi district. The results of the current study indicated that 58.7% of raw milk produced and sold in the study area in the wet season exceeded the East African Standards limits for TBC and can be considered as poor in quality. Education interventions on methods of producing quality milk are highly encouraged.

**Keywords:** Bacteriological Quality, Milk hygiene, Raw Milk, Total Bacteria Count, Total coliform count, Total Staphylococcus Count

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## Introduction

Fresh milk drawn from a healthy cow normally contains a low microbial load (less than 1000/ml), but the microbes may increase up to 100 fold or more once it is stored for some time at ambient temperatures (Grimaud *et al*., 2009). Milk produced under hygienic conditions from healthy animals should not contain more than 5 x 105 cfu/ml microbial load (Bereda *et al*., 2012; Fatine *et al*., 2012). East African Community standards specify that, Grade A milk should contain less than 200 000 bacteria/ml and milk containing more than 1 000 000 cfu/ml should not be accepted for processing (EAS 67, 2007). Pasteurized milk should have not more than 30 000 TBC/ml (EAS 69, 2006).

The presence of zoonotic pathogens poses a serious public health hazard to the producer and consumers of raw milk and other milk products (Mdegela *et al*., 2009). There exists the possibility of consuming milk, which contains disease causing organisms originating directly from the cow or through environmental contamination. In tropical countries where high temperatures and lack of refrigeration limits production and storage of fresh milk, it has traditionally been used as fresh immediately after milking, by boiling , or by processing into more stable products such as fermented milk.

The environment where milk is produced has a great influence on the quality of milk produced. Furthermore, the quality of a dairy product is highly determined by the milk handling practices by smallholder dairy farmers (Abebe *et al*., 2012; Worku *et al*., 2012). Lack of refrigeration facilities at the farm and increased level of milk handling, is also a limiting factor for production of good quality milk (Kurwijila *et al*., 1995; Omore *et al*., 2005). Conversely, milk testing and quality control may be done to satisfy the demand for high quality milk by consumers and dairy processors (Mdegela *et al*., 2009). Unfortunately, in developing countries like Tanzania the monitoring of milk quality from production to market is not conducted regularly and the quality control methods employed at collection points often cannot detect the level of microbial contamination.

There have been efforts to promote milk production in the Southern Highlands zone for decades with the objectives of improving nutrition through increased milk consumption and income generation for smallholder dairy farmers. The main areas of focus have been on genetic improvement, promotion and improving performance of marketing and consumption of milk and dairy products, veterinary extension services and pasture establishment (Kifaro, 1995, Kabungo *et al*., 2011). Little focus has been placed on the quality of the product being produced. Thus, the study aimed to determine the microbial quality of milk produced and marketed in Mbeya region at production to marketing points. The study hypothesized that milk marketed in the study area has low microbiological quality than levels recommended by EAS.

## Materials and Methods

*Study area*

The study was carried out in Mbeya and Mbozi districts which have a high population of dairy cattle in Mbeya region. Description of the study area can be found in Massawe *et al*., (2018).

*Study design and sampling procedure*

A cross-sectional study was conducted to determine the TBC, TCC and TSC in milk from dairy farmers' herds, milk collection points and milk shops in two districts of Mbeya region. The sample sizes for households keeping dairy cattle and milk samples for microbiological analysis were calculated by the formula described by Fox *et al*., (2007). The household sample size was based on the proportion of dairy farmers (4%) in the two districts (NBS, 2013). The sample size for milk was based on prevalence of 20.4 % of S. aureus reported in Tanzania (Mdegela *et al*., 2004). Sample size was determined at 95% confidence interval and 5% margin for random error where N = P (100% - P)/ (SE) 2, SE = MRE/1.96.

Where; N = Sample size, P = Prevalence of subclinical mastitis, SE = Standard error, MRE = Margin for random error (5%) and 1.96 = tabular value for 95% confidence interval.

From above formula, sample size was as follows; 96 herd milk samples, 18 samples from milk collection points and 36 samples from milk shops. Furthermore two more samples (boiled and soured milk) were collected from each milk shop for microbial analysis. The criterion for household inclusion in the sampling frame was any household composed of at least one lactating dairy cow during the study period.

*Sampling procedure*

Twelve villages were randomly selected by using a table of random numbers, from a sampling frame comprised of a list of all villages in the study area, which were obtained from the District Livestock office. Proportional sampling was adopted to obtain the number of villages from each of the two study districts. Within each village eight households, two collection points and three milk shops were randomly selected for milk sampling. (In this study milk collection points were selected based on the presence of cooling facility, container for receiving and storing milk, quality control and members capable of collecting not less than 150 litres per day. Two of these had milk cooling tanks while 16 used refrigerators and cold water for cooling of milk).

Samples were collected between 6.15 am and 7.30 am, and 4.15 pm and 6.30 pm from farmers herds, milk collection centre and milk shops. Samples were collected in sterile universal bottles of 50 ml with a screw lid and kept in a cool box at less than 4oC and then transported to the Tanzania Livestock Research Institute (TALIRI), Uyole, and stored at -20oC. The next day after morning collection, samples were transported to Sokoine University of Agriculture (SUA) and the microbiological analysis was performed within 36 hrs.

*Laboratory analysis*

Enumeration of TBC, TCC and TSC were performed by using standard procedures (ISO 6888-1, 1999). Briefly, tenfold serial dilutions of each milk sample were prepared using sterile peptone water. Initially dilutions of 10-2 to 10-10 were used in order to establish the best dilution to be used in the test samples. Dilutions of 10-2 to 10-7, 10-2 to 10-4 and 10-2 to 10-4 were found appropriate for TBC, TCC and TSC counts, respectively. For the determination of TBC, 0.1 ml of each dilution was transferred using a sterile pipette and spread on Plate Count (PC) agar using a separate sterile glass spreader for each sample. The plates were then kept in an incubator at 30oC for 24-48 hours. Following incubation, colonies were counted with the aid of a colony counter. Total Coliform Count and TSC were also determined by following the same procedure but differences in incubation temperature (37oC,) and agar MacConey agar (Oxoid) and Manitol salt agar (Oxoid) were used for TCC and TSC, respectively.

*Statistical analysis*

The extent of microbial contamination of each sampling point was transformed into log10 values and data was analyzed by using SAS (2002). The General Linear Model (GLM) procedure was used to compare the extent of milk contamination between the sampling points (Farmer, collection points and milk shops) and season (dry and wet). Significant levels were defined at $P<0.05$.

Statistical model

$$Y_{ijkl} = \mu + L_i + D_j + S_k + LD_{ij} + SL_m + SD_n + \square_{ijk..} 1$$

Where

$Y_{ijk}$ = TBC, TCC and TSC of ith location in jth sampling points and kth seasons.

$\mu$= overall mean common to all observation $L_i$= the effect of ith location

$D_j$= the effect of jth sampling points (source) (where 1=Herd level, 2 = Collection point, 3 = Milk shops

$S_k$ = the effect of Kth seasons (where 1= wet and 2=dry)

LDI = the effect of kth interaction of location and sampling points

$SL_m$ = the effect of mth interaction of location and seasons

$SD_n$ = the effect of nth interaction of seasons and sampling points and $\square_{ijkl}$ = Random error team

## Results

The overall mean for TSC in Mbeya district was significantly ($p<0.05$) higher than in Mbozi district (Fig 1). The results further showed that there were no statistical ($p>0.05$) differences observed for TBC and TCC between the districts.

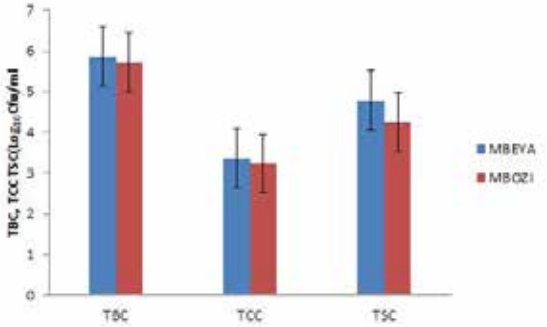



**Figure 1:** Overall mean for TBC, TCC and TSC (log10Cfu/ml) (with standard error bar) in Mbeya and Mbozi districts, Tanzania

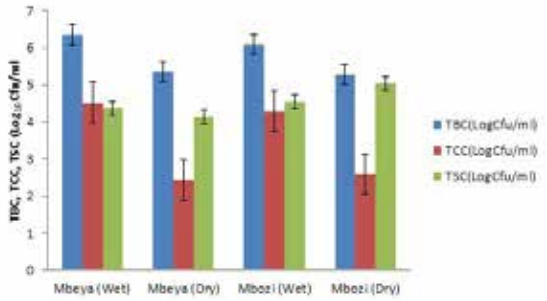



**Figure 2:** Overall bacteriological mean count (with standard error bars) in wet and dry season in Mbeya and Mbozi districts, Tanzania

Figure 2 showed the overall mean for TBC, TCC and TSC in wet and dry season in the study area. The results showed that TBC and TCC was significant ($p<0.001$) higher in wet than in the dry season for both districts. TSC was significantly ($p<0.05$) higher in dry season in Mbozi district and no significant difference was observed in Mbeya district.

Regarding the source of milk, TBC differed significantly ($P<0.001$) along the collection points (Table 1). There was a significant increase in TBC from farmers' bulked milk to milk collected in the milk shops. Total Coliform Count had non-significant ($p>0.05$) difference for milk collected from farms and milk collection points, where as TCC in milk from these two points differed significantly ($p<0.05$) with milk collected from milk shops in Mbeya district. In Mbozi district TCC from farmers bulked herd milk differed significantly ($p<0.05$) with milk from collection point and Milk shops. Furthermore, TSC had non-significant ($P>0.05$) increase between the source and districts, though there were slight numerical increments from farmers' herds to milk shops (Table 1).

The effects of source and season on microbial quality in the study areas are shown in Table 2. TBC and TCC in the milk collected from farmers bulk herds differs significantly ($p< 0.001$) between the seasons where the wet season had higher values compared to the dry season. However, no statistically significant ($p>0.05$) difference was observed in the case of TSC between farmers and seasons.

In the milk collection points the results showed that milk collected from Mbozi district's collection points had significantly ($p<0.05$) lower TBC in the wet compared to the dry season. Furthermore, TCC in the milk of both districts were significantly ($p<0.05$) higher in the wet season than in the dry season. The milk from Mbozi collection points contained significantly ($p<0.05$) lower TSC count in the wet season than in the dry season. No differences were observed for TSC in Mbeya district in relation to season.

The microbial quality in milk collected from the milk shops showed significantly ($p<0.05$) lower TBC in the dry season compared to the wet season for both districts. TCC differed significantly ($p<0.05$) between the districts in the dry season where Mbozi had significantly lower TCC. There was no significant difference in TSC for milk collected from Mbeya and Mbozi in both seasons.

**Table 1:** Effects of source of milk on bacterial quality of raw milk along the milk collection point in Mbeya and Mbozi districts, Mbeya, Tanzania.

| District | N | Source | TBC(log10cfu/ml) | TCC(log10cfu/ml) | TSC(log10cfu/ml) |
|---|---|---|---|---|---|
| Mbeya | 48 | Farmer | 4.02 ± 0.59$^{c}$ | 3.13 ± 0.86$^{a}$ | 3.89 ± 0.58 |
| | 18 | MCP | 5.96 ± 0.48$^{b}$ | 3.23 ± 0.69$^{a}$ | 4.01 ± 0.72 |
| | 36 | Milk shop | 6.73 ± 0.65$^{a}$ | 2.10 ± 0.94$^{b}$ | 4.18 ± 0.79 |
| Mbozi | 48 | Farmer | 3.88 ± 0.49$^{c}$ | 3.07 ± 0.71$^{a}$ | 3.79 ± 0.59 |
| | 18 | MCP | 5.82 ± 0.53$^{b}$ | 2.05 ± 0.76$^{b}$ | 4.53 ± 0.63 |
| | 36 | Milk shop | 7.47 ± 0.56$^{a}$ | 2.18 ± 0.81$^{b}$ | 4.89 ± 0.68 |

*Means with the same superscript within a row do not differ significantly (P>0.05). Lsmean ±SE–Least square means, Standard error. Cfu/ml – Colony forming unit per milliliter. TBC – Total bacteria count, TCC – Total coliform count, TSC – Total staphylococcus count*

**Table 2:** Effect of Source and Season on bacteriological quality of raw along the milk collection point in Mbeya and Mbozi, district, Tanzania

| Milk source | N | Parameter | Wet | | Dry | |
|---|---|---|---|---|---|---|
| | | | Mbeya | Mbozi | Mbeya | Mbozi |
| | | | Lsmean ±SE ($Log_{10}$cfu/ml) | Lsmean±SE ($Log_{10}$cfu/ml) | Lsmean ±SE ($Log_{10}$cfu/ml) | Lsmean±SE ($Log_{10}$cfu/ml) |
| Farmer | 48 | TBC | 3.66± 0.61$^{a}$ | 3.49 ± 0.52$^{a}$ | 3.06 ± 0.62$^{b}$ | 3.12 ± 0.52$^{b}$ |
| Farmer | 48 | TCC | 3.96 ± 0.89$^{a}$ | 3.59 ± 0.75$^{a}$ | 2.24 ± 0.89$^{b}$ | 1.10 ± 0.75$^{b}$ |
| Farmer | 48 | TSC | 4.25 ± 0.75$^{a}$ | 3.50 ± 0.63$^{a}$ | 3.95 ± 0.75$^{a}$ | 3.92 ± 0.63$^{a}$ |
| MCP | 18 | TBC | 4.63 ± 0.72$^{b}$ | 5.85 ± 0.64$^{a}$ | 4.51 ± 0.72$^{b}$ | 5.08 ± 0.64$^{b}$ |
| MCP | 18 | TCC | 3.91 ± 1.04$^{a}$ | 2.80 ± 0.93$^{a}$ | 1.31 ± 1.04$^{b}$ | 1.81 ± 0.92$^{b}$ |
| MCP | 18 | TSC | 4.43 ± 0.88$^{a}$ | 3.01 ±0.78$^{b}$ | 4.11 ± 0.88$^{a}$ | 3.72 ± 0.78$^{a}$ |
| Milk shop | 36 | TBC | 6.51 ± 0.49$^{a}$ | 6.93 ± 0.57$^{a}$ | 4.30 ± 0.57$^{b}$ | 5.06 ± 0.57$^{b}$ |
| Milk shop | 36 | TCC | 4.05 ± 0.70$^{a}$ | 3.71 ± 0.83$^{ab}$ | 2.80 ± 0.83$^{b}$ | 1.64 ± 0.83$^{c}$ |
| Milk shop | 36 | TSC | 3.95 ± 0.59$^{a}$ | 4.21 ± 0.70$^{a}$ | 4.08 ± 0.70$^{a}$ | 4.19 ± 0.70$^{a}$ |

*Means with the same superscript within a row do not differ significantly (P>0.05). Lsmean ±SE–Least square means, Standard error. Cfu/ml – Colony forming unit per milliliter. TBC – Total bacteria count, TCC – Total coliform count, TSC – Total staphylococcus count*

**Table 3:** Bacteriological quality for Soured/Fermented and Boiled hot milk sold in milk shop in Mbeya and Mbozi districts in the wet and dry seasons

| STATUS | N | Parameter | Wet | | Dry | |
|---|---|---|---|---|---|---|
| | | | Mbeya | Mbozi | Mbeya | Mbozi |
| | | | Lsmean ±SE ($Log_{10}$cfu/ml) | Lsmean±SE ($Log_{10}$cfu/ml) | Lsmean ±SE ($Log_{10}$cfu/ml) | Lsmean±SE ($Log_{10}$cfu/ml) |
| Boiled hot | 36 | TBC | 2.65± 0.79$^{b}$ | 3.07±0.61$^{ba}$ | 1.90 ±0.69$^{c}$ | 3.27±0.77$^{a}$ |
| Boiled hot | 36 | TCC | 2.93±1.15$^{a}$ | 2.71 ± 0.90$^{a}$ | 1.13±1.02$^{b}$ | 1.29±1.14$^{b}$ |
| Boiled hot | 36 | TSC | 1.45±0.94$^{c}$ | 3.71±0.73$^{a}$ | 2.35±0.83$^{cb}$ | 3.08±0.70$^{b}$ |
| soured | 36 | TCC | 3.11±1.08$^{a}$ | 3.16 ±1.23$^{a}$ | 2.27±1.22$^{b}$ | 2.15±0.96$^{b}$ |
| soured | 36 | TSC | 3.11±0.87$^{b}$ | 2.93±1.01$^{b}$ | 3.19±0.99$^{b}$ | 4.35±0.78$^{a}$ |

*Means with the same superscript within a row do not differ significantly (P>0.05). Lsmean ±SE–Least square means, Standard error. Cfu/ml – Colony forming unit per milliliter. TBC – Total bacteria count, TCC – Total coliform count, TSC – Total staphylococcus count*

Table 3 shows the microbiological quality of ready-to-consume milk sold at Milk shops. Generally in the dry season boiled hot milk collected from Mbeya milk shops had significant ($p<0.05$) lower TBC compared to the milk collected from Mbozi milk shops. No statistical significant difference was observed for the milk collected in wet season between the milk shops in both districts. Furthermore, the results showed that TCC in boiled hot milk had significantly ($p<0.05$) higher counts in the wet season compared to the dry season in both districts. TSC was significantly ($p<0.05$) lower in the wet season in Mbeya than in Mbozi district and no statistical differences were observed in the dry season between the two districts.
Regarding cultured milk, the results showed that milk sold in Mbeya milk shops had significantly ($p<0.05$) lower TCC than in Mbozi in the dry season. No statistical differences were observed in TCC and TSC in the wet season in both districts. However TSC in cultured milk collected from Mbozi district was significantly ($p<0.05$) higher in dry than wet season. There was no significant difference observed for this parameter in Mbeya district.

## Discussion

The results of this study showed that the mean TBC was moderately high when compared to EAS (EAS 67, 2007). According to the East African community standards of raw milk (EAS 67, 2007), good quality raw milk should have TBC of less than 5.3 log10 cfu/ml for the milk intended for further processing. The presence of high bacterial load in milk could be due to the unhygienic milking practices, dirty animal houses, the unhygienic environment and general milk handling may have resulted into contamination of the raw milk. Another reason could be the absence of cooling facilities in the production level thing which was not practiced by the majority of farmers. The results of this study are comparable with other done in other part of Tanzania by Kivaria *et al*., (2006) and Karimuribo *et al*., (2015) and also in other countries like Bangladesh (Khan *et al*., 2008) and Ghana (Addo *et al*., 2011). Higher value of 7.36 -7.88 and 7.07 log10 cfu/ml have been reported in Ethiopia by Worku *et al*. (2012) and Mosu *et al*., (2013), respectively.

According to East African Community standards for TCC of raw milk (EAC 67, 2007), good quality raw cow milk should not exceed TCC counts of 4.69 log10 cfu/ml. Based on the East African Standards the mean (3.46 log10cfu/ml) TCC obtained in this study was within the recommended range of good quality milk of 3.0 to 4.69 log10 cfu/ml. Coliform are used as indicator bacteria and their presence in milk implies that other enteric pathogens may be present. Poor housing conditions have been mentioned to be a source of contamination for housed cows, mainly from bedding material which are mixed with cow dung and urine (Oliver *et al*.,2005). In this study it was observed that most of house of cows were dirty and the bedding used was soiled with dung and urine. Milking cows in such an area can leads into contamination of milk with Coliform bacteria. This finding concurs with that from other studies in Ghana (Addol *et al*., 2011) and in Tanzania (Swai and Schoonman, 2011).

Mean TSC counts obtained in this study were above 4 log 10 cfu/ml. The observed counts could be due to the lack of personal hygiene, procedures followed during milking and post milk handling. Also the presence of subclinical mastitis among the dairy herds could be another reason which influences the increased TSC in raw milk. Currently no established standard for TSC in East Africa, however, even low counts do not assure safety because the organism can grow and produce enterotoxins especially for species like Staphylococcus aureus. TSC in the raw milk samples obtained in this study are comparable to the report by Hossain *et al*., (2011) who found the TSC in the raw milk to range from 5.7×104 to 1.48×106 cfu/ml. Higher TSC counts of 7.37 ± 0.57 log 10 cfu/ml have been reported in Sudan by Rahamtalla *et al*., (2016).

The bacteriological quality at each milk source in the dry and wet seasons showed that TBC and TCC for the milk collected at farmer level varied between seasons, particularly that significant higher count was observed in the

wet season than in the dry season. Seasons affected zero grazing cow cleanliness with a significantly higher percentage of dirty cow sheds, dirty cows and soiled udders being observed during the wet season compared to the dry season (Massawe *et al*., 2018). High soil moisture during the wet season favour growth of microorganisms that contaminate milk under poor hygienic conditions in smallholder dairy farms. Similar result was reported by Nateghi *et al*., (2014) in Iran where higher microbial counts were observed in winter than summer. Higher microbial counts in summer have been reported in Romania, Iran and Sudan by Popescu *et al*., (2014), Najand and Rezaii (2014) and Suliman and Mohamed (2010), respectively. It was observed in the study areas that during the wet season the environment in which animals were housed and milked, was poor compared to dry season and this may have contributed to the higher microbial counts in the wet season.

TSC in milk at farm level was higher in both seasons and 65% of the collected samples had counts value of 104 and above. The source of contamination could be from milk handlers or cows with subclinical mastitis, handling utensils and storage temperature. The source of staphylococcus species is difficult to trace due to its ubiquitous nature. For example S. aureus is carried in the nose of some 20% to 30% of persons, who also carry this bacteria in their skin and it is frequently observed in cows with subclinical mastitis (Jørgensen *et al*., 2005; Peles *et al*., 2007). The dominance of Staphylococcus species in the incidence of subclinical mastitis has also been reported in studies conducted in Tanzania (Mdegela *et al*., 2004, 2009; Kivaria *et al*., 2006) and poor milking practices and hygiene were the reason mentioned for the dominance of this group of pathogens.

Microbial milk qualities of raw milk sold in the milk shops in wet season had TBC counts below grade III of EAS 67(2007). The observed higher counts are an indication of poor handling along the market chain, storage and time taken to sell the milk received. The results are in line with finding reported in Tanga, Tanzania by Swai and Schoonman (2011) that raw milk marketed was of poor quality.

The effects of milk source on bacteriological quality showed that the TBC in the milk collected from collection points and milk shops had significantly higher counts compared to farmer's bulked milk. The results showed that the TBC increases as the level of handling is increased. This result concurs with the report by Omore *et al*., (2005) in Kenya and Amitsu *et al*., (2015) in Ethiopia that the microbial quality of milk deteriorates from farmers to selling points. The reason for the increased TBC at this level is that the process of collecting small quantities of milk from many small holder dairy farmers takes a considerably long period of time which affects the time of cooling down the milk and hence gives a chance for bacteria to multiply.

It was observed that TCC in milk had a significant difference between the collection sources. Higher counts were observed at farmers' levels while lower counts were recorded at milk shops. Based on EAS67 (2007), the values of TCC obtained were within the recommended limits. This couldbe attributed to the dilution effects as milk shops receive milk from different sources of varying levels of coliform counts. Other reasons could be the death of coliform bacteria because their viability decreases with keeping time and in most cases hot water with soap was used to wash the milk handling utensils.

Most of milk shops in the study area sold ready-to-consume boiled hot and cultured/sour milk. The results showed that values of TCC were higher in boiled hot milk than the recommended limit for EAS 69 (2006). It is well known that Coliform bacteria do not survive pasteurization and or effective boiling, so their presence in the boiled milk (ready-to-consume) indicates ineffective boiling or recontamination after boiling. EAS 69 (2006) recommended pasteurized/boiled milk to have 10cfu/ml, higher values of TCC have been reported by Hossain *et al*., (2011) who found the coliform count of 1.2 x106cfu/ml.

Total staphylococcus counts for boiled hot and cultured/sour milk were higher than the level recommended in most of milk shops. A higher staphylococcus species (e.g.

Staphylococcus aureus) count has been related to production of enterotoxins which cause food poisoning (Peles *et al*., 2007).

Gratian (2012) reported that 22.27% of boiled hot milk collected from Temeke had S. aureus. Insufficient boiling, poor hygiene during handling of the milk or serving the milk using dirty utensils have been mentioned as sources of this bacteria in the boiled milk (Kitagwa *et al*., 2006). Therefore, effective boiling, clean serving utensils and appropriate storage conditions of milk can reduce microbial contamination of the milk sold in the milk shops and safeguard the health of consumers.

## Conclusion and recommendation

It can be concluded that milk quality decreases from production to the milk marketing point. This is ascribed to the increased handling and subsequent microbial multiplication during transportation to the selling points. TBC and TCC were higher in the wet seaseon than in the dry season along the value chain. Moreover, boiled hot and cultured /sour milk (ready-to-consume) sold in milk shops in the study areas had higher TBC and TCC counts than that recommended in the EAS.

Currently there are no standards for TSC in East Africa, thus it is high time for the responsible authority to set standards for TSC because some of the species e.g. Staphylococcus aureus are important pathogens which cause food poisoning worldwide.

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## Competing interests

The authors declare that they have no competing interest and this document is their original research work done in the Southern Highlands Zone of Tanzania and no part of it has been submitted somewhere else for conference presentation or publication.

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# INCIDENCE OF FOETAL WASTAGES IN SHEEP AND GOATS SLAUGHTERED AT FUNAKAYE MAIN ABATTOIR, GOMBE STATE

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## Abstract

The Study was carried out to determine the number of sheep and goats slaughtered and incidence of foetal wastages in Funakaye main abattoir, Gombe State. The research lasted for six months between May to October, 2014. There was no significant difference between the two species, although more goats were slaughtered during the study period compared to sheep. Similarly there was also no significant difference between male and female sheep slaughtered. In contrast, there was a significant ($p<0.01$) difference between male and female goats slaughtered. The incidence of foetal wastages between May to October in both species did not show any significant differences across months. There was a significant ($p<0.001$) difference in age distribution of goats slaughtered during the study period. Furthermore there was a significant ($p<0.001$) difference in age distribution of sheep slaughtered across months. In addition the breed distribution of sheep showed significant ($p<0.05$) effects across the breeds studied. There was also significant ($p<0.01$) difference in the breed distribution of goats across months. It could therefore be concluded that indiscriminate slaughter of small ruminants especially the females leads to the decline of Livestock populations as well as losses of a huge amount of money. It could therefore be recommended that livestock farmers and abattoir inspectors should be educated on how to detect pregnancy in sheep and goats especially in the early stages. Appropriate legislation should be put in place by the government in order to allow effective monitoring of animals during ante mortem examination in the abattoir to minimize losses.

**Keywords:** Abattoir, Foetal wastages, Legislation, Funakaye, Gombe

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## Introduction

Nigeria has been estimated as having the third largest population of livestock in Africa with about 87.6 million animals (UNIDO, 2001); cattle15.4 million (17.6%), goats 44.1 million (50.3%), sheep 28 million (31.9%) and camels 18,000 (0.21%). On the other hand, there is a substantial difference between published livestock production figures and the actual number of animals due to poor record keeping and illegitimate slaughter outside abattoirs particularly with the slaughter of cattle, sheep and goats UNIDO, (2001). Furthermore, a large number of animals slaughtered and imported on hooves through the borders into the country are mostly unrecorded and this leads to unreliable data on the animal numbers.

Abattoirs or slaughter-houses are needed primarily to serve the large-scale demand for meat in urban areas where there are no livestock. It is a matter of economic and hygienic importance which has long been recognized and utilized during slaughter of livestock (Eisnitz, 1997; Philip and Temple, 2001). Slaughterhouses are used to dress animals for the efficient distribution of meat and meat products to the community. The obligation in the conversion of food animals to edible products is to slaughter the animals in a humane manner and to process the carcass in hygienic conditions in an efficient way (Phillip and Temple, 2001).

So far there is a dearth of information and limited research findings on the incidence of foetal wastages at the Funakaye main abattoir. This research was designed therefore to study the incidence of foetal wastages in sheep and goats slaughtered at the Funakaye main abattoir, Gombe state.

## Materials and methods

*Location*

Funakaye is a Fulfulde compound word literally meaning east side of hill". It is located 60km North of the state capital (Gombe State). Funakaye emirate is about one hundred and ten (110) years old. The Local Government Area was created in October, 1996 by the military government of the late General Sani Abacha and was carved out of the former Nafada-Bajoga Local Government. The area has a land mass and population of 237, 687 (NPC 2006). It is bordered by Dukku local government in the West, Nafada local government in the North, Kwami local government in the south and Yobe state in the east. The Funakaye main abattoir is 2km south of the headquarters Bajoga and different breeds of animals are slaughtered in this facility.

*Climate condition*

The local government area is located near a transition zone between Sudan Savannah region, which is characterized by short trees and grasses. Two seasons are usually experienced annually, the dry season of about 6-7 months which usually starts from November to April, while the rainy season starts from May to October. The climate is generally hot with average annual temperatures of 32-40 oC. The rainfall is usually accompanied with thunderstorms. The hottest months of the year are March and April with average temperatures of 39-43°C.

*Study area*

The study was carried out at Funakaye main abattoir. The main sources of animals slaughtered at the abattoir are the surrounding or neighboring markets like Malam-Sidi, Kuri and others such as Dukku, Kumo and Dadin-kowa markets. The animals are bought by retailers from Fulani rearers and other peasant farmers within the state or bordering states like Bauchi, Yobe and Borno states.

*Data collection*

In addition to the daily visits to the abattoir during the study period, data on the daily slaughter of different livestock species at Funakaye main abattoir from May to October 2014 were obtained from the record of monthly reports from the Ministry of Agriculture and Natural resources of Funakaye local Government.

*Statistical analysis*

Chi-square analysis was used to compare variables.

## Results

There was no significant difference between the two species, although more goats were slaughtered during the study period compared to sheep (Table 1). Similarly there was also no significant difference between male and female sheep slaughtered but in contrast, there was significant ($p<0.01$) difference between male and female goats slaughtered (Table 2). The incidence of foetal wastages between May and October in both species did not show any significanct differences across months (Table 3). There was a significanct ($p<0.001$) difference in age distribution of goats slaughtered during the study period (Table 4). Furthermore there was a significant ($p<0.001$) difference in age distribution of sheep slaughtered across months (Table 5). In addition the breed distribution of sheep showed significant ($p<0.05$) effects

**Table 1:** The number of Sheep and Goats of Slaughtered in Funakaye Main Abattoir Gombe state

| Month | No. of Sheep | No. of Goat | $X^2$ |
|---|---|---|---|
| May | 168(12.3) | 280(13.3) | |
| June | 288(21.0) | 472(22.4) | |
| July | 258(18.8) | 398(18.9) | 8.862NS |
| August | 227(16.6) | 363(17.3) | |
| September | 111(8.1) | (186(8.8) | |
| October | 319(23.2) | 404(19.2) | |
| **Total** | **1369** | **2103** | |

*Key: NS -Non significant percent in parenthesis.*

**Table 2:** Number of sheep (Rams and Ewes) and Goat (Bucks and Does) Slaughtered in Funakaye Main abattoir Gombe State

| Months | Sheep | Male | Female | X2 | Goats | Male | Female | $X^2$ |
|---|---|---|---|---|---|---|---|---|
| May | 168 | 88(12.8) | 80(11.7) | | 280 | 114(10.2) | 166(16.8) | df= 5 |
| June | 288 | 149(23.8) | 139(20.4) | | 247 | 248(22.2) | 224(22.6) | |
| July | 258 | 117(18.7) | 141(20.6) | | 398 | 209(18.7) | 189(19.1) | |
| August | 227 | 94(15.0) | 133(19.5) | NS | 363 | 177(15.9) | 186(18.8) | 54.394xxx |
| September | 111 | 61(9.7) | 50(7.3) | | 186 | 95(8.5) | 91(9.2) | |
| October | 317 | 117(28.2) | 140(20.5) | | 404 | 273(24.5) | 131(31.3) | |
| **Total** | **1369** | **626** | **683** | | **2103** | **1116** | **987** | |

*Key: NS -Non significant percent in parenthesis.*

**Table 3:** Incidence rate of foetal wastages of Slaughtered Ewes and Does in Funakaye Main Abattoir Gombe state

| Month | No. of Foetuses in Sheep | No. of Foetuses Goat | $X^2$ |
|---|---|---|---|
| May | 8(10) | 10(12.0) | |
| June | 10(7.2) | 14(16.9) | |
| July | 5(3.5) | 24(28.9) | 11.081 NS |
| August | 6(4.5) | 7(8.4) | |
| September | 11(22) | 7(8.4) | |
| October | 9(6.4) | 21(35.3) | |
| **Total** | **49(7.2)%** | **83(8.4)%** | |

*Key: NS -Non significant percent in parenthesis.*

**Table 4:** Age Distribution of Goats slaughtered in Funakaye main Abattoir Gombe State Age in Months

| Month | 0 – 12 | 13 – 24 | 25 – 36 | 37 – 48 | $X^2$ |
|---|---|---|---|---|---|
| May | 33(11.1) | 62(16.1) | 81(14.6) | 104(13.2) | |
| June | 39(13.2) | 69(17.8) | 154(27.7) | 210(26.6) | |
| July | 32(10.8) | 97(25.1) | 97(17.5) | 172(21.8) | 112.732*** |
| August | 56(18.9) | 74(19.2) | 77(13.9) | 136(17.3) | |
| September | 42(14.2) | 41(10.6) | 37(6.7) | 66(8.4) | |
| October | 94(31.8) | 103(26.7) | 108(91.5) | 100(12.7) | |
| **Total** | **296** | **386** | **554** | **788** | |

*Key: *** (p<0.001) percent in parenthesis.*

**Table 5:** Age distribution of sheep slaughtered in Funakaye main Abattoir Gombe State Age in Months

| Month | 0 – 12 | 13 – 24 | 25 – 36 | 37 – 48 | $X^2$ |
|---|---|---|---|---|---|
| May | 27(16.6) | 33(11.0) | 35(10.7) | 73(15.0) | df=3 |
| June | 53(32.7) | 70(23.4) | 57(17.7) | 108(22.2) | |
| July | 37(22.8) | 60(20.1) | 79(24.5) | 82(16.9) | 39.736*** |
| August | 10(6.2) | 30(10.0) | 36(11.2) | 71(14.6) | |
| September | 8(4.9) | 29(9.7) | 35(10.7) | 38(8.0) | |
| October | 27(16.7) | 77(25.8) | 80(24.8) | 113(27.4) | |
| **Total** | **162** | **299** | **322** | **486** | |

**Table 6:** Breeds Distribution of sheep in Funakaye main Abattoir Gombe State

| Breeds | May | June | July | August | September | October | $X^2$ |
|---|---|---|---|---|---|---|---|
| Yankasa | 69(5.0) | 109(7.9) | 101(7.3) | 89(6.5) | 48(3.5) | 158(11.5) | df=5 |
| Uda | 33(2.4) | 68(4.9) | 66(4.8) | 71(5.2) | 30(2.2) | 63(4.6) | |
| Balami | 58(4.2) | 101(7.4) | 78(5.7) | 59(4.3) | 27(2.0) | 86(6.3) | 25.333* |
| Sudanese | 8(1.0) | 10(1.4) | 13(1.0) | 8(1.0) | 6(4.0) | 10(0.4) | |
| **Total** | **168** | **288** | **258** | **227** | **111** | **317** | |

**Table 7:** Breeds Distribution of Goats in Funakaye main Abattoir Gombe State

| Breeds | May | June | July | August | September | October | $X^2$ |
|---|---|---|---|---|---|---|---|
| Red Sokoto | | | | | | | |
| 131(6.2) | 200(9.5) | 165(7.8) | 139(6.6) | 82(3.4) | 203(9.7) | df=5 | |
| Kano Brown | 82(3.8) | 120(5.7) | 118(5.6) | 117(5.6) | 59(2.8) | 119(5.6) | |
| Borno White | 61(2.9) | 143(6.8) | 99(4.7) | 88(4.1) | 38(1.8) | 82(3.9) | 50.470*** |
| Sahel Goats | 6(0.2) | 9(0.4) | 20(1.0) | 19(1.0) | 7(0.3) | 0(0) | |
| **Total** | **280** | **472** | **398** | **363** | **186** | **404** | |

*Key: *** (p<0.001) Percent in parenthesis.*

across the breeds studied (Table 6). There was also a significant ($p<0.01$) difference in the breed distribution of goats across months (Table 7).

## Discussion

*Animal slaughtered*

The finding on the animal species contribution as a source of meat in Funakaye main abattoir is in line with the earlier work by Adewale (1985) and Butswat (1994) that sheep and goats were known as sources of meat in Gombe, Bauchi, Ibadan and Oyo states. This study observed that goats were favored by livestock consumers as a source of meat as reported by Ikeme (1990) who stated that goats were slaughtered more than any other species of animals and are preferred by most Nigerian cultures. Meat and meat products of small ruminants are important commodities occupying a special place in the diet of many communities in Nigeria and account for 30% of total meat consumed in sub-Saharan Africa (Ikeme, 1990). Goats were known for their high contribution to meat supply although seasonal variation exist in the contribution of meat supply (Butswat, 1994).

Halle *et al* (1995) reported that the least number of goats slaughtered is during the late dry and early wet seasons. Furthermore, Waba (2006) reported that the contribution of goats to meat supply was much mor`e in the early rainy seasons than in all other seasons.

The contribution of sheep as a source meat has been studied and revealed that sheep were more slaughtered significantly during the late wet seasons (August to October) due to the hypothermic condition which usually occurrs during the heavy wet season, killing ewes and lambs especially when they are kept under the traditional system of housing (open sided roof housing) or outside (Waba, 2006). Generally, there were high slaughters of female animals in the early wet season as reported by Garba *et al* (1992) who stated that female species are mostly sold out when they look heavier to fetch more money for economic reasons. The slaughter of pregnant animals was observed during the late rainy seasons throughout the study and this is in line with the work of Voh *et al* (1993) who reported that the slaughter of 3-4 months pregnant does and ewes may be due to the fact that the animals appear heavier and consequently sell better than non-pregnant ones. Osinowo (1992) reported that high reproductive activities in animals producing meat and milk are due to the availability of feeds or pastures. Abdullahi (2003) stated that the dropping of the economic climax of livestock development in Nigeria is attributed among many factors to the indiscriminate culling through slaughter of actively reproducing and pregnant animals.

*Foetal wastages from pregnant animals*

There seems to be a progressive increase in the number of pregnant animals slaughtered causing foetal death in our abattoirs which were mainly due to human negligence (Voh *et al*., 1993). Most of the animals slaughtered at the abattoir were from agro-pastoralists who dispose of their animals irrespective of their reproductive status to fulfill social obligations (Abdullahi *et al*., 2008). This has contributed immensely to the economic recession in the livestock sub-sector witnessed in Nigeria since the 1980s. The incidence of foetal deaths was mostly as a result of the slaughter of pregnant animals during the study period (May to October). Foetal wastages were high in October (35.3%) and low in May (10%). This result is in agreement with that of Voh *et al*., (1993) who stated that the tendency for better pregnancy rates during the rainy season is due to the availability of pasture.

## Conclusion

It was evident that small ruminants were slaughtered for food much more in the late wet season and most of the female animals were sold for consumption. This led to a decline in livestock population as well as losses of huge amounts of money through indiscriminate slaughter of animals particularly sheep and goats.

## Recommendation

It is necessary to seriously harness and safeguard against the indiscriminate slaughter of productive and pregnant animals in order to avoid a rapid decline in the livestock population. A legislative order has to be instituted to guide against rampant slaughter of productive and pregnant females. Female animals intended for slaughter should undergo pregnancy testing by competent and skilled animal scientists or veterinarians before slaughter. Farmers and butchers should be enlightened on the implication of the slaughter of productive and pregnant female animals.

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# USING PARTICIPATORY EPIDEMIOLOGY TO EXPLORE LIVESTOCK HUSBANDRY SYSTEMS AND RELATIVE IMPORTANCE OF SMALL RUMINANT'S DISEASES AMONGST PASTORALISTS IN SOKOTO STATE, NIGERIA.

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## Abstract

Pastoralists are faced with several challenges that may ultimately impinge on the general protein supply in Nigeria. Participatory Epidemiology tools were used to evaluate economics of livestock species kept by pastoralists along with some husbandry challenges in 3 Local Government Areas (LGAs) in Sokoto State, Nigeria. Data were subjected to descriptive statistics, Friedman's test and Kendall's coefficient of concordance. Livestock kept were ranked; cattle (1), then goats (2), sheep (3), poultry (4) camels (5) and donkeys (6). Economic benefits derived from these animals were fertilizer, means of livelihood, transport, traction, emergency fund, festivities, meat and milk/milk products. Militating factors against livestock production in these communities were ranked as; diseases (1), lack/inadequate shelter (2), effects of transhumance (3), conversion of cattle routes to crop-land (4), cost of medication (5), feeding (6) and lack of watering points (7). Median score for factors militating against livestock production was significantly different ($p < 0.05$). Important small ruminants diseases identified and their scores were Foot and mouth disease (1), pox (2), peste des petits ruminants (3), helminthosis (4), fasciolosis (5), contagious caprine pleuropneumonia (6), catarrh (6), brucellosis (6) and Foot rot (6). Clinical signs of identified diseases were consistent with the modern Veterinary knowledge of such diseases. Diseases and several management factors were found to militate against livestock production. Pastoralists were found to be a repository of Veterinary knowledge and should be given a voice to enhance understanding of animal health problems in their localities and the options for their prevention, control and surveillance using PE.

**Key Words:** Participatory epidemiology, livestock, husbandry, diseases, Sokoto State, Nigeria

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## Introduction

Pastoralists in Nigeria are the predominant meat, milk and leather products providers via animal farms. The livelihoods of these pastoralists are threatened by factors ranging from diversion of cattle routes to cropland leading to pasture-shortages, decreasing access to water, livestock ailments among others (Goswami, 2016). These factors do not only concern pastoralists but also affect the entire food security of Nigerians in general. In view of the importance of these threats and the fact that the Nigerian economy has been agrarian even before the discovery of oil minerals in the 1950s, researchers in this field need to employ a method suitable for exploring vital information from these pastoralists which may pave way for exploring lasting solutions to these threats. In many developing countries, investigating livestock impediments in pastoralists' settings is a major challenge. This is because the pastoralists live in the most remote areas which are characterized by relatively scanty but highly mobile human populations involved in moving their livestock across large areas with few accessible roads or means of modern communication and poor infrastructure (de Leeuw *et al*. 1995). Therefore, conducting meaningful research in such settings is limited as this goes along with less motivated personnel and limited financial resources (Allport *et al*. 2005). In view of this, researchers in the field of veterinary epidemiology came up with a more practicable approach, the Participatory Epidemiology (PE) techniques to improve investigation on livestock in such areas (Catley, 2005; Thrusfield 2005). An important feature of the PE is the use of learning and analytical methods with communities, which enables them to express their knowledge and priorities in their own language, thereby reducing the non-sampling errors commonly found in questionnaire surveys (Catley, 2006). Participatory Epidemiology is a proven technique which overcomes many of the limitations of conventional epidemiological methods, and has been used to solve a number of animal health surveillance and research problems in Africa and Asia (Catley, 2006; Jost *et al*. 2007).

This study describes the use of PE to collect information on the livestock husbandry systems and relative importance of small ruminants' diseases amongst pastoralists in Sokoto state, Nigeria.

## Materials and Methods

*Study Area*

The study was conducted in Sokoto State which is located between longitude 110 30° and 130 50°E and latitude 40 and 60 40° N. It shares common borders with the Tahowa Province of Niger Republic to the north, Kebbi State to the west and South, Zamfara State to the east and south (SERC, 2005). The State also falls in the Sudan Savannah in the southern part and the Sahel in the northern part. The State comprises of 23 Local Government Areas (LGAs) and occupies a land mass of about 25,973 square kilometres with a human population of about 3,696,999 (NPC, 2006). For the purpose of this study, 3 LGAs namely; Illela, Tambuwal and Yabo were randomly selected from the 23 LGAs making up the State (fig 1).

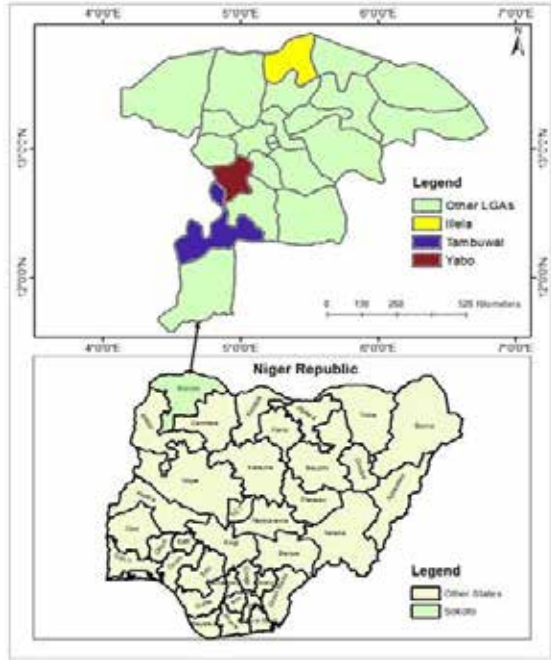



**Figure 1:** Map of Nigeria highlighting Sokoto State and study area

*Formation of PE Team and selection of focus group Participants*

A participatory epidemiology team of 3 was formed in each LGA under study. This consisted of an interviewer/facilitator who took lead of the interview, a livestock officer-in- charge of the LGA who served as a key informant and a recorder who was the Veterinarian in charge of the LGA and was also responsible for the interpretation of the local names of diseases mentioned by participants into the conventional scientific names. The respondents/participants were selected from amongst members of the community in each study area and comprised mostly of pastoralists of various age groups. Interviews were conducted in one district from each of the selected LGAs in the State based on ease of accessibility.

*Field work and use of PE tools*

Visits to villages were scheduled in line with the convenience of all participants. Locations and timing of the interviews were arranged prior to the visit by the key informant. Each focus group comprised of an average of 10 participants. Of all the PE tools, those that best suited the information sought were used. A combination of tools was used in some villages with probing questions to ascertain the consistency of information provided by the respondents where necessary. Focus group interviews were conducted and the consistency of information obtained was maintained with the aid of a check-list as described by Mariner and Roeder (2003). Interviews were conducted in the Hausa Language which was the language understood by all respondents and was later translated into the English Language.

*Determination of husbandry problems and predominant small ruminant diseases*

Using a semi structured format of interview, Participants in the villages visited were asked to mention the following:

a. All animal species they kept in their community.
b. Problems militating against livestock production in their community.
c. Major diseases affecting livestock in general and small ruminants in particular.

The listed items were written individually on pieces of (63.5×52.2cm) cardboard paper, after which a simple ranking tool was employed where a representative of the group was asked to rank the listed items. Listed animal species were ranked based on population, problems militating against livestock production, and diseases affecting livestock were ranked in order of their importance, starting from the most important to the least important. The economic importance of each listed animal species was arrived at through use of a semi-structured interview (SSI). Time was given for all the participants to come to a consensus before the information was recorded in a log book. During the SSI, names of the identified diseases were given in the Hausa/Fulani language after which they were translated to the English language by the Veterinarian in charge of the respective LGA.

*Determination of livestock species kept by participants*

Proportional pilling was used to determine the previous information given by the pastoralists. The method described by Catley *et al*. (2009) was used. This involved drawing of circles on a cardboard paper corresponding to the number of animal species mentioned previously, after which a sketch of each animal species was drawn in each of the circles. One hundred maize grains were provided as counters and the participants were asked to pile the relative population of each species. Time was given to allow for agreement among all the participants on the distribution of counters before the results were recorded.

*Determination of diagnostic ability of pastoralists on brucellosis and other Small Ruminant diseases*

To find out the pastoralists' understanding of clinical indicators for small ruminant diseases, a matrix scoring method was used. Simple matrices were drawn on a 63.5×52.2cm cardboard paper with diseases written in their local names on the top axis

(x-axis) as mentioned by the pastoralists and their major clinical signs (indicators) written on the vertical axis (y-axis). For each clinical indicator, participants were given 30 grains of maize as counters (AFENET, 2011) and were asked to score each indicator on how it relates to a particular small ruminant disease. They were given some time to come to a consensus amongst themselves before it was recorded.

*Determination of animal health care and existing ethnoveterinary practices of pastoralists*

Semi Structured Interviews were used where pastoralists' focus groups were asked to mention various traditional practices employed in treating common livestock diseases. The information given was documented in a log book. They were further asked where applicable to show and say how these herbs were used in treating these livestock ailments. Pictures of identified herbs were taken.

*Verification of information and expressions obtained during the interview*

Transect walk was conducted across the villages after the other activities were completed. This helped to make direct observation of the village settlement and to verify some of the information given by the pastoralists. It also gave an opportunity of members of the team to meet and conduct informal interviews with other rural dwellers not involved in the initial interviews. Information on the community's efforts towards livestock management/production systems were observed and recorded. Clinical cases of diseases were observed and pictures were taken where necessary.

*Statistical analysis of data*

Descriptive statistical analysis was used to describe basic features of the data from participatory epidemiology using 3 main statistical approaches that included distribution of data, Central tendency and Dispersion. Also, data were exported to SPSS version 17.0 (2009) where Kendall's coefficient of concordance (W) was used to measure levels of agreement among different informant groups. Other data were presented as pictures and charts.

## Results

*Species and estimated population of livestock kept by pastoralists*

Simple ranking and proportional piling of livestock species kept by pastoralists in Sokoto State showed that cattle constituted the largest proportion (ranked 1st), this was followed by goats (ranked 2nd), sheep (ranked 3rd), poultry (ranked 4th), camels (ranked 5th) and Donkeys (ranked 6th) as presented in Plate I.




**Plate I:** Proportional pilling of animals kept by pastoralists in Sokoto State.

*Economic significance of livestock species kept by pastoralists*

Semi structured interviews (SSIs) with pastoralists in Sokoto State showed that economic benefits derived from the animal they kept included fertilizer, means of livelihood, draft power, farm traction, source of emergency fund, festivities, meat and milk/milk products.

With regards to cattle, the matrix scoring procedure showed that fertilizer, farm traction and means of livelihood had 6 scores each, milk/milk products and draft scored 4, meat scored 3, festivities scored 1 and emergency fund scored 0. As for sheep, means of livelihood and emergency fund scored 8, meat and festivities scored 6, fertilizer scored 2, farm traction, milk/milk products and draft power all scored 0. For goats, meat and emergency fund scored 8, means of livelihood scored 5, milk/milk products scored 4, festivities and fertilizer scored 3 and 2 respectively while farm traction and draft scored 0. Regarding camels, farm

traction scored 7, milk/milk products scored 6, meat, means of livelihood and draft power all scored 5, fertilizer, and festivities both scored 1 while emergency fund scored 0. As for poultry, emergency fund scored 11, festivities scored 8, means of livelihood and meat scored 7 and 4 respectively while fertilizer, farm traction, milk/milk products and draft power all scored 0. All scores were 0 for the donkey except draft power which had a score of 30. Fertilizer, means of livelihood and draft power scored 6 each while farm traction scored 5, milk/milk products scored 3, festivities and meat scored 2 and emergency fund scored 0. For sheep, the highest score of 11 was allocated to festivities, emergency fund scored 8, meat scored 5, means of livelihood and fertilizer scored 4 and 2 respectively, draft, farm traction, milk/milk products all scored 0. As for goats emergency fund scored 11, means of livelihood and meat score 5, festivities scored 4, milk/milk products and fertilizer scored 3 and 2 respectively while 0 score was allocated to draft and farm traction. With regards to poultry, emergency fund was allocated 15 scores, festivities scored 7, meat and means of livelihood scored 5 and 3 respectively while fertilizer, draft, farm traction, milk/milk products all scored 0. As for the donkey, all the variables had scores of 0 except for draft power with a score of 30 (Plate II).

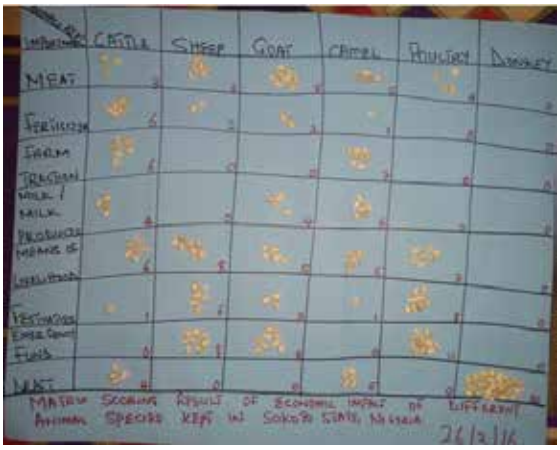



**Plate II:** Matrix scoring for economic impacts of animal species kept by pastoralists in Sokoto State, Nigeria.

*Factors militating against livestock production in pastoralists herds*

Factors militating against livestock production by the simple ranking method were; diseases (Rank 1 =; Z = 1.73), lack of / inadequate shelter (Rank 2 =; Z = 1.46), effects of transhumance (Rank 3 =; Z = 1.1), conversion of cattle routes to cropland (Rank 4 =; Z = -0.46), cost of medication (Rank 5 =; Z = 1.28), feeding (Rank = 6; Z = -1.28) and lack of watering points (Rank 7 = ; Z = -1.28) (Table 1). There was no significant difference in the median scores for livestock husbandry problems ($p > 0.05$).

*Predominant diseases affecting small ruminants as identified by pastoralists*

Using SSI, pastoralists in the study area identified and ranked 7 diseases/conditions commonly affecting small ruminants which included; Chabo {Foot and mouth disease (FMD)} (Rank = 1; Z = 1.97), Ado/Gaye (pox) (Rank = 2 ; Z = 1.82), Dan kap {peste des petits ruminant (PPR)} (Rank = 3; Z = 1.63), matsattsaku (helminthosis) (Rank = 4; Z = 1.16), balku (fasciolosis) (Rank = 5; Z = -0.94), huhu {contagious caprine pleuropneumonia (CCPP)} (Rank = 6; Z = -0.94), Mura (catarrh) (Rank = 6; Z = -0.94), bakkale (brucellosis) (Rank = 6; Z = -0.94), ciwon kofoto (Fot rot) (Rank = 6; Z = -0.94) as determined by pairwise ranking. The median scores for these small ruminant diseases were significantly different ($p < 0.05$) as presented in Table 2.

*Evaluation of Pastoralists' ability to diagnose small ruminant diseases*

Pastoralists interviewed associated signs of 'ado' (pox) in small ruminants to be high morbidity 16 (12-20), high mortality 2 (0-4), seasonal occurrence 3 (0-6), abortion 2 (2-3), respiratory distress10 (5-15), mouth erosion/salivation 2 (0-4), limping 1 (0-2), inappetence 12 (10-15), fever 5 (4-7) and skin involvement 30 (30-30) (Table 3). For 'balku' (fasciolosis) in small ruminants, the indicators identified were high morbidity 11 (12-20), high mortality 3 (0-5), seasonal occurrence 7 (5-8), inappetence 15(10-20), fever 8 (5-10), liver involvement 25 (20-30) and diarrhoea 5.5 (3-8).

**Table 1:** Scores for estimated husbandry problems that affect production as reported by herdsmen in Sokoto State, Nigeria.

| Problem | Mean (%) | Median (%) | Range (%) | Z-Score | Rank |
|---|---|---|---|---|---|
| Diseases | 3 | 3 | 2 | 1.73 | 1 |
| Lack/Inadequate shelter | 2.5 | 3 | 1 | 1.46 | 2 |
| Effects of transhumance | 2 | 2 | 2 | 1.1 | 3 |
| Diversion of cattle routes to cropland | 0.5 | 0 | 1 | -0.46 | 4 |
| Cost of medication | 0 | 0 | 0 | -1.28 | 5 |
| Feeding | 0 | 0 | 0 | -1.28 | 6 |
| Lack of watering points | 0 | 0 | 0 | -1.28 | 7 |

*H = 10.63; df = 6; p = 0.1004*

**Table 2:** Scores for estimated importance of small ruminant diseases as reported by herdsmen in Sokoto State, Nigeria

| Disease | Local Names | Mean (%) | Median (%) | Range (%) | Z-score | Rank |
|---|---|---|---|---|---|---|
| FMD | Chabo | 2 | 2 | 2 | 1.97 | 1 |
| Pox | Gaye/Ado | 1 | 1 | 2 | 1.82 | 2 |
| PPR | Iska/Dan kap | 1.7 | 4 | 4 | 1.63 | 3 |
| Helminthosis | Matsattsaku | 2.7 | 2 | 3 | 1.16 | 4 |
| Fasciolosis | Balku | 1.7 | 0 | 0 | -0.94 | 5 |
| CCPP | Huhu | 0 | 0 | 0 | -0.94 | 6 |
| Catarrh | Mura | 0 | 0 | 0 | -0.94 | 6 |
| Brucellosis | Bakkale/Bari | 0 | 0 | 0 | -0.94 | 6 |
| Footrot | Ciwon kofoto | 0 | 0 | 0 | -0.94 | 6 |

*H = 22.43, df = 8, p = 0.0131*

As for 'bakkale' (brucellosis) in small ruminants, the signs associated were high morbidity 5 (0-8), high mortality 2 (0-4), seasonal occurrence 1 (0-2), abortion 25 (20-30), inappetence 1 (0-2) and fever 1 (0-2). With regards to 'chabo' (FMD), the indicators were high morbidity 18 (10-25), high mortality 6.5 (3-10), seasonal occurrence 4 (0-8), mouth erosion/salivation 25 (20-30), limping 27.5 (25-30), inappetence 6 (15-20) and fever 12.5 (15-20). As for 'dan kap' (PPR), the signs were high morbidity 20 (15-25), high mortality 27.5 (25-30), seasonal occurrence 10 (5-15), abortion 1.5 (0-3), respiratory distress 18 (12-25), mouth erosion/salivation 11 (4-18), inappetence 17.5 (15-20), fever 22.5 (20-25) and diarrhoea 25 (20-30). High morbidity 15 (5-25), high mortality 3 (0-6), seasonal occurrence 5 (0-10), abortion 1 (0-2), inappetence 1.5(0-3), fever 0.5 (0-1) and diarrhoea 15 (10-20) were signs associated with 'matsattaku' (helminthosis). As for 'mura' (catarrh), high morbidity 3 (0-5), high mortality 2 (0-4), seasonal occurrence 10 (5-15), abortion 2 (0-3), respiratory distress 15 (10-20), inappetence 5 (2-8) and fever 4 (2-6) were the indicators identified. Kendall's coefficient (W) of concordance also showed strong agreements for these indicators between the focus groups as shown in Table 3.

*Pastoralists' Traditional Veterinary Practice*

Using the SSI as a PE tool, the pastoralists reported that, due to lack of or inadequate access to Veterinary services in their villages, they resorted to using herbs and other traditional means to treat livestock ailments. They also strongly believed that these traditional treatment methods were more

**Table 3:** Matrix scores of clinical indicators for characterization of small ruminant diseases by pastoralists in Sokoto State, Nigeria

| Clinical Indicators (W) | Diseases | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ado (pox) | Balku (Fasciolosis) | Bakkale (Brucellosis) | Chabo (FMD) | Dan kap (PPR) | Matsattsaku (Helminthosis) | Mura (catarrh) |
| High morbidity (0.863***) | 16 (12-20) | 11 (12-20) | 5 (0-8) | 18 (10-25) | 20 (15-25) | 15 (5-25) | 3 (0-5) |
| High mortality (0.920***) | 2 (0-4) | 3 (0-5) | 2 (0-4) | 6.5 (3-10) | 27.5 (25-30) | 3 (0-6) | 2 (0-4) |
| Seasonal (0.333*) | 3 (0-6) | 7 (5-8) | 1 (0-2) | 4 (0-8) | 10 (5-15) | 5 (0-10) | 10 (5-15) |
| Abortion (0.925***) | 2 (2-3) | 0 (0-0) | 25 (20-30) | 0 (0-0) | 1.5 (0-3) | 1 (0-2) | 2 (0-3) |
| Respiratory distress (0.647**) | 10 (5-15) | 0 (0-0) | 0 (0-0) | 0 (0-0) | 18 (12-25) | 0 (0-0) | 15 (10-20) |
| Mouth erosion/salivation (0.862**) | 2 (0-4) | 0 (0-0) | 0 (0-0) | 25 (20-30) | 11 (4-18) | 0 (0-0) | 0 (0-0) |
| Limping (0.933***) | 1 (0-2) | 0 (0-0) | 0 (0-0) | 27.5 (25-30) | 0 (0-0) | 0 (0-0) | 0 (0-0) |
| Inappetence (0.825***) | 12 (10-15) | 15(10-20) | 1 (0-2) | 16 (15-20) | 17.5 (15-20) | 1.5(0-3) | 5 (2-8) |
| Fever (0.604**) | 5 (4-7) | 8 (5-10) | 1 (0-2) | 12.5 (15-20) | 22.5 (20-25) | 0.5 (0-1) | 4 (2-6) |
| Skin involvement (1.000***) | 30 (30-30) | 0 (0-0) | 0 (0-0) | 0 (0-0) | 0 (0-0) | 0 (0-0) | 0 (0-0) |
| Liver involvement (0.934***) | 0 (0-0) | 25 (20-30) | 0 (0-0) | 0 (0-0) | 0 (0-0) | 0 (0-0) | 0 (0-0) |
| Diarrhoea (0.719**) | | 0 (0-0) | 5.5 (3-8) | 0 (0-0) | 0 (0-0) | 25 (20-30) | 15 (10-20) |

*Cells showed median scores (range) for clinical sign against a corresponding disease; maximum obtainable score = 30;W = Kendall's coefficient of concordance (*P < 0. 5; **P < 0.01; ***P < 0.001). PPR= Pestes de petit Ruminante; FMD = Foot and Mouth Disease*

**Table 4:** Ethno veterinary remedies for livestock ailments in Katsina and Sokoto States, Nigeria.

| Ailment | Ethno veterinary approach | Route of administration |
|---|---|---|
| Retained Placenta | Fresh panicle of sorghum (Sorghum bicolor) | Oral |
| | Soaked 'tsaban gatari' (metal part of an axe) with 'ban adu'a' (Balanites aegyptiaca' bark) | Oral |
| Diarrhoea | Crushed leaves of 'kuka' (Adansonia digitata) in water. | Oral |
| Bloat | Mixture of 'gogai' (Stiga germoatheca) in groundnut oil | Oral |
| PPR | Mixture of 'kanwa' (pottash) with 'tafarnuwa' (Allium sativa) | Oral |
| FMD | Crushed onion (Allium sepa) | Topical |
| | Paste of Lime and 'Bagaruwa' (Acacia nilotica). | Topical |
| | Fermented 'tuwo' (Cooked grain) | Topical |

effective, more readily available and more affordable than the orthodox medicine. Some of the herbs used for traditional remedies and mode of application are shown in Table 4.

## Discussion

This study highlighted several factors which could help in explaining the epidemiology of certain small ruminant diseases through management/husbandry practices by pastoralists in their settlements in Sokoto State. In addition, the traditional veterinary knowledge believed to have been transferred from generation to generation of pastoralists in the State, serves as an eye-opener for future research which may go a long way in standardizing such treatment protocols. Generally, an understanding of their husbandry systems and the relative importance of diseases of small ruminants prevalent in their settlements is crucial when formulating policies and developing technologies that support small ruminant production in these holdings.

In this study, cattle were found to be the most populous species of livestock in pastoralists' holdings in Sokoto State. This may be due to the fact that, in pastoralists' settings, cattle are kept as a status symbol and cultural medium (Tibi and Aphunu, 2010). The pastoralists attach more prestige and economic significance to cattle rather than other livestock species. Small ruminants in this setting, are mainly regarded as the property of women and children (Dossa *et al*., 2008) and are mostly consumed on a day to day basis especially in villages. They are also mostly utilised during festivities and are commonly presented as gifts. Their involvement in these activities perhaps may account for their relatively lower population. Amongst the small ruminant species, goats were found to have a higher population than sheep. However, the reasons for this have not been fully elucidated as reported in FAOSTAT (2003). In our view, it may be connected to the fact that the goats have more multiple births than the sheep and are able to thrive better in harsh conditions. Also, in a study conducted by Abdullahi *et al*. (2011), it was reported that consumption of goat meat is hindered by some cultural taboos in Sokoto State. Besides, the ovine species are more involved in festivities like 'Sallah' and naming ceremonies in the Northern part of Nigeria.

The study further demonstrated that, the pastoralists derive several economic benefits from different livestock species they keep. These livestock species were principally a means of survival in most villages visited. They have considerable potential to contribute towards improving food and nutritional security, enhancing agricultural growth, reducing rural poverty and mitigating farm households'

vulnerability to crop production shocks (Alary *et al*., 2011, Birthal and Negi, 2012). During the dry season, cattle, sheep and goats graze on the farmlands and consequently fertilize such farmlands thereby reducing the cost and risk of using inorganic fertilizers (Jigme *et al*., 2015). The study also showed that work bulls were used for draft power and farm traction on farms and also served as sources of income for the owners as they hired out to other farmers. In general, most of the animal species kept by pastoralists have multiple economic advantages, except for donkeys which were only used for draft power. This report is in agreement with Khan *et al*. (2015) who reported that donkeys are mostly used for transportation of a variety of goods.

Pastoralists in Sokoto State identified diseases, lack of/inadequate shelter, effects of transhumance, conversion of cattle routes to cropland, cost of medication, feeding and lack of watering points as husbandry problems that affected livestock production. This finding is in agreement with the report of Bamaiyi (2013) who listed some of these factors among the 14 factors militating against animal production in Nigeria. These factors if adequately addressed may guarantee an aspect of food security in Nigeria since these pastoralists are the backbone of Nigeria's livestock production.

Pastoralists in their own way seem to have some understanding of epidemiology. They could clearly identify some clinical indicators with certain common diseases they encounter in their villages. In most instances, these indicators tallied with those commonly taught on such diseases in Veterinary schools. However, there could be possibilities of concurrent infections which may not be reflected in the farmers' observations. There may therefore be the need for further evaluations by Veterinarians with a view to educating the farmers to enhance disease surveillance and reporting.

Furthermore, from the study, the interviewees reported using certain plants for the treatment of livestock diseases. This wealth of traditional knowledge by these pastoralists is strongly believed to have been transferred from the old to the young folk as reported by Kaltungo (2012); Buhari, (2014); Abdullahi *et al*. (2017). The findings in this study agree with those of other researchers who reported that despite limited levels of formal education among pastoralists, they are key in helping researchers in the investigations relating to knowledge of local diseases, their symptoms and the local remedies to such diseases. They also help in designing plans and initiatives to for surmounting their local problems (Catley *et al*. 2012; Disa, 2016).

## Conclusion

In general, a wealth of information was generated through the use of PE which ordinary structured questionnaires would not have been able to accomplish due to several limitations associated with structured questions to fully address the worries of rural communities. Thus, PE could prove handy in obtaining excellent information directly from the primary sources. It also has added advantages of being fast and less costly for gathering information and also ensures confidence of the respondents from whom the information is sourced. The involvement of the local community also facilitates subsequent follow-up plans and intervention strategies because the process involves the active participation of target communities (Bett *et al*. 2009). It also helps to reveal rare sources of traditional knowledge that can be used to develop orthodox medical approaches in animal health care delivery.

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# PREVALENCE OF REPRODUCTIVE PROBLEMS AND ASSOCIATED RISK FACTORS OF COWS IN SMALLHOLDER LIVESTOCK PRODUCTION SYSTEM IN AND AROUND AMBO TOWN, ETHIOPIA

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## Abstract

The study was conducted in and around Ambo town in West Shewa Zone of the Oromia Regional State, Ethiopia from November, 2014 to April, 2015. The objective of the study was to identify the major reproductive problems of cows and their associated risk factors in the study area. During the study period 384 cows were examined for mastitis using the California Mastitis test for screening of subclinical mastitis. A questionnaire survey was conducted with the cow owners enquiring about different reproductive problems and associated risk factors. In the present study 153(40%) cows were found to have been affected by at least one of the reproductive problems except mastitis. Retained placenta 51(13.3%) followed by Anestrous 31(8.1%) and repeat breeder 26 (6.8%) were the major problems encountered. In this study, body condition (P= 0.00), age (p= 0.027), parity (p= 0.027) and housing (P= 0.01) were found to be associated significantly with reproductive problems. The prevalence of the reproductive problems were significantly higher in cows with medium body conditions 68(17.7%), 5-8 years old 82(21.4%), 1-3 parity 82 (21.4%), and indoor housed cows 77(20.1%). The overall prevalence of mastitis was 42.7 % with higher subclinical mastitis cases (32%). With regard to clinical mastitis housing had significant effect (p= 0.015). On subclinical mastitis, breed (p= 0.005) and housing (p= 0.018) were found to be significantly associated. The current study indicated the importance of reproductive problems as one of impediments in the production of small holder dairy cows and requires strategic interventions in good management practice.

**Key words:** dairy cow, mastitis, prevalence, reproductive problems, small holder

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## Introduction

Ethiopia is a largely rural country with an agrarian economy. Agrarian economy is the most important agricultural activity in many countries throughout the world (Mamabolo and Webb, 2005). Livestock are of economic and social importance both at the household and at national levels. Although estimates vary widely, livestock is thought to contribute 15–17% of Ethiopian gross domestic product (GDP), 47% of agricultural GDP and 37–87% of the household incomes; the large variations are due to climatic variation (ICPALD, 2013).

Ethiopia is believed to have the largest livestock population in Africa estimated at about 70.79 million head of cattle, 28.48 million sheep,25.91 million goats,24.56 million donkeys, 11.39 million horses, 8.08 million mules, 8.39 million camels, 42.51 million poultry and 71.62 million beehives (CSA, 2011).

The estimates of cattle for the rural sedentary areas in the country are about 53.4 million. Out of this total cattle population, the female cattle constitute about 55.5% and 98.95% of the total cattle in the country are local breeds. The hybrid and exotic breeds account for about 0.94% and 0.11%, respectively (CSA, 2013).

Reproductive problems of cattle are one of the major problems in Ethiopia. Among the common forms of reproductive problems in cows is anestrus, repeat breeding, retained placenta, abortion, dystocia, uterine and vaginal prolapse and mastitis (Khair *et al*., 2013).

There are various reasons for infertility and reproductive disorders, which often affect lactations. Some of the causes of infertility are complex and there is interrelation between predisposing factors (Gizaw *et al*., 2007) such as management at calving, hygiene and parity, stage of gestation, hereditary and congenital factors, nutrition and environment (Msangi *et al*., 2005).

There are numerous studies done to determine the reproductive problems of dairy cows in Ethiopia. A prevalence of 37.1% in Ada'a district by Esheti and Moges (2014) and 67.7% in Borena by Benti and Zewdie (2014) were reported. Studies have not been conducted on the reproductive problems of cows in smallholder farms in and around Ambo town. So the current study aimed to identify the major reproductive problems and associated risk factors of smallholder dairy cows in the Ambo, West Shewa, Ethiopia.

Livestock have multiple uses aside from income generation, including cash storage, cropping activities, draught power, transport, fuel, food and various cultural uses (Peden *et al*., 2007). Livestock play an important role in these farming systems, as they offer opportunities for risk coping, farm diversification and intensification, and provide significant livelihood benefits (Bossio, 2009).

Despite the significantly large livestock population, its contribution to the national economy is below the potential due to challenges in livestock production systems that include technical, institutional and socio-economic constraints (MoA, 2013). These constraints result in poor reproductive performance of dairy cattle. These constraints cause considerable economic losses to the dairy industry due to reduced reproductive performance and cost of treatment (Lobago *et al*., 2006).

## Materials and Methods

*Study area*

The study was conducted in and around Ambo town in West Shewa Zone of the Oromia Regional State from November, 2014 to April, 2015. Ambo town, the capital city of West Shewa Zone, is the administrative center of the Zone located at a latitude and longitude of 8°59$^0$N 37°51$^0$E8.983°N 37.85°E and an elevation of 2101 meters above sea level (masl) and 114 km west of Addis Ababa. The zone is divided into three main agro-climatic zones: highland, midland and lowland region. The study areas receive a bimodal rain fall of long rainy season covering June to September and the remaining in the short rainy season with a mean annual rainfall of 900mm (800 – 1000 mm) and annual temperature ranging from 15$^0$c to 29$^0$c with average temperature of 22°C.

The study area has large cattle populations which indicates its suitability for animal production. The topography of the zone, which is mainly leveled field, makes it an ideal place for agriculture (Bainesagn, 2016). The farming system of the study area is characterized by a mixed (crop- livestock production) farming system.

*Study population*

The study population was female cattle at reproductive age (above the age of 3 years) in the study area. Sampled animals constituted different age groups, body condition score, breed and housing conditions, and numbers of parity.

*Study design and sample size determination*

A multistage cross-sectional study was conducted on selected female animals. The Primary sampling unit is selected town of Ambo from West Shewa zone of Oromia Regional National State. The Secondary sampling units are randomly selected small holder dairy farms. The third stage sampling units are randomly selected reproductive female cows in the farm. The study constituted questionnaire survey and milk sample collection for determination of subclinical mastitis and different risk factors that potentially contribute for the reproductive problems. The sample size required for this study was determined based on sample size determination in random sampling for infinite population using 50% expected prevalence of *bovine* trypanosomes in the area and 5% desired absolute precision and at 95% confident level, using the formula described by Thrusfiled (2005). Accordingly the total sample size was determined to be 384 animals. Body condition for each cattle was estimated based on previously described method (Nicholson and Butterworth 1986) with scale ranging from 1 (emaciated) to 5 (obese). The age of the animals was determined by the dentation method described by Food Safety Inspection Service (2013).

## Sample collection method

*Questionnaire survey*

A questionnaire survey was administered to 384 animal owners. The owners were first briefed about the objectives of the study and then questions were asked about major reproductive problems like abortion, dystocia, retained placenta, anestrous, repeat breeder, clinical mastitis, uterine and vaginal prolapsed, and some risk factors including housing, breeding and parity.

*Milk Sample collection and laboratory analysis*

The milk was collected from the four teats of the selected 150 lactating cows and pour milk from each teat in four California mastitis test (CMT) chambers separately, then examining immediately. The milk sample was collected for CMT according to the method described by Michael McFadden (2011) to determine subclinical mastitis.

*Data Management and Analysis*

The questionnaire and sample results were entered into Microsoft Excel spread sheet. Then Descriptive statistical data analysis technique was used to calculate percentages. Statistical associations between risk factors were calculated by using Chi-square test in SPSS version 20 (IBM, 2011). Statistical significance of results was set at P value less than 0.05 and with 95% confidence level and 0.05-desired absolute precision.

## Results

The present study revealed that 153 (40%) cows were affected at least by one of the reproductive problems except mastitis. Among these reproductive problems retained placenta was with the highest prevalence 51 (13.3%) followed by anestrous 31 (8.1%) and repeat breeder 26 (6.8%) (Table 1).

In the current study prevalence of the reproductive problems were significantly higher ($P<0.05$) in medium body conditioned 68(17.7%), 5-8 years old 82(21.4%), 1-3 calves parity number 82 (21.4%) and indoor housed 77(20.1%) (Table2).

**Table1:** Summary of questionnaire survey result of prevalence of reproductive problems of cows except mastitis in and around Ambo town

| Type of problems | Positive/affected animals | Prevalence (%) |
|---|---|---|
| Abortion | 22 | 5.7 |
| Dystocia | 19 | 5 |
| Retained placenta | 51 | 13.3 |
| Anestrous | 31 | 8.1 |
| Vaginal prolapsed | 3 | 0.8 |
| Uterine prolapsed | 1 | 0.3 |
| Repeat breeder | 26 | 6.8 |
| **Total** | **153** | **40** |

**Table 2:** Prevalence and association of reproductive problems except mastitis of cows with breed, body condition, age, parity, breeding, housing and origin in and around Ambo town

| Risk factors | Category of risk factors | No.of animals examined | Positive/ affected animals | Prevalence (%) | X2 | P-value |
|---|---|---|---|---|---|---|
| Breed | Cross | 118 | 50 | 13 | 1.726 | 0.189 |
| | Local | 266 | 94 | 24.5 | | |
| | Total | 384 | 144 | 37.5 | | |
| Body condition | poor | 92 | 51 | 13.3 | 18.424 | 0.00 |
| | Medium | 228 | 68 | 17.7 | | |
| | Good | 64 | 25 | 6.5 | | |
| | Total | 384 | 144 | 37.5 | | |
| Age | 3-5 | 75 | 19 | 4.9 | 7.241 | 0.027 |
| | 5-8 | 214 | 82 | 21.4 | | |
| | >8 | 95 | 43 | 11.2 | | |
| | Total | 384 | 144 | 37.5 | | |
| Parity | Heifer | 75 | 19 | 4.9 | 7.241 | 0.027 |
| | 1-3 calves | 214 | 82 | 21.4 | | |
| | >3 calves | 95 | 43 | 11.2 | | |
| | Total | 384 | 144 | 37.5 | | |
| Breeding | NM | 260 | 94 | 24.5 | 0.623 | 0.43 |
| | AI | 124 | 50 | 13 | | |
| | Total | 384 | 144 | 37.5 | | |
| Housing | Indoor | 173 | 77 | 20.1 | 6.6 | 0.01 |
| | Outdoor | 211 | 67 | 17.4 | | |
| | Total | 384 | 144 | 37.5 | | |
| Origin | Ambo town | 194 | 81 | 21.1 | 3.24 | 0.198 |
| | Far and senk | 110 | 38 | 9.9 | | |
| | Awaro | 80 | 25 | 6.5 | | |
| | Total | 384 | 144 | 37.5 | | |

** AI: Artificial insemination, Far and san: Farisi and senkele, NM: Natural mating*

On this study significantly higher retained placenta prevalence was observed in cows with age between 5 and 8, parity frequency between 1 and 3. Poor body condition cows were with significantly higher anestrous; while significantly higher ($p<0.05$) repeat breeder were observed in cows age between 5-8 years and parity between 1and 3. Prevalence of abortion was significantly higher ($p<0.05$) in cows breed with artificial insemination, while it has no significance on dystocia (Table3).

The overall prevalence of mastitis was 42.7 % with higher subclinical mastitis cases (32%). (Table 4).

**Table 3:** Prevalence of reproductive problems and associated risk factors

| Risk factors | No. exam. | Animals affected and prevalence (%) in different reproductive problems | | | | |
|---|---|---|---|---|---|---|
| | | Retained placenta | Anestrous | Repeat breeder | Abortion | dystocia |
| **Breed** | | | | | | |
| Cross | 118 | 35(9.1) | 18(4.7) | 19(4.9) | 14(3.6) | 11(2.9) |
| Local | 266 | 16(4.2) | 13(3.4) | 7(1.8) | 8(2.1) | 8(2.1) |
| $X^2$(P-val) | | 0.011(0.915) | 1.989(0.158) | 0.19(0.663) | 0.348(0.555) | 1.215(0.27) |
| **B/ cond.** | | | | | | |
| Poor | 92 | 15(3.9) | 17(4.4) | 8(2.1) | 8(2.1) | 4(1) |
| Medium | 228 | 31(8.1) | 11(2.9) | 6(1.6) | 12(3.1) | 11(2.9) |
| Good | 64 | 5(1.3) | 3(0.8) | 12(3.1) | 2(0.5) | 4(1) |
| $X^2$(P-val) | | 2.412(0.299) | 17.653(0.0) | 21.278(0.0) | 2.394(0.302) | 0.309(0.857) |
| **Age** | | | | | | |
| 3-5 | 75 | 0 | 9(2.3) | 10(2.6) | 0(0) | 0(0) |
| 5-8 | 214 | 31(8.1) | 14(3.6) | 14(3.6) | 15(3.9%) | 13(3.4) |
| >8 | 95 | 20(5.2) | 8(2.1) | 2(0.5) | 7(1.8) | 6(1.6) |
| $X^2$(P-val) | | 16.738(0.0) | 2.25(0.325) | 8.411(0.015) | 5.68(0.058) | 4.86(0.088) |
| **Parity** | | | | | | |
| Heifer | 75 | 0 | 9(2.3) | 10(2.6) | 0(0) | 0(0) |
| 1-3 calf | 214 | 31(8.1) | 14(3.6) | 14(3.6) | 15(3.9) | 13(3.4) |
| >3 calf | 95 | 20(5.2) | 8(2.1) | 2(0.5) | 7(1.8) | 6(1.6) |
| $X^2$(P-val) | | 16.738(0.0) | 2.25(0.325) | 8.411(0.015) | 5.68(0.058) | 4.86(0.088) |
| **Breeding** | | | | | | |
| Natural | 260 | 34(8.9) | 24(6.2) | 17(4.4) | 10(2.6) | 10(2.6) |
| Artificial | 124 | 17(4.4) | 7(1.8) | 9(2.3) | 12(3.1) | 9(2.3) |
| $X^2$(P-val) | | 0.029(0.864) | 1.455(0.228) | 0.069(0.793) | 5.286(0.021) | 2.078(0.149) |
| **Housing** | | | | | | |
| Indoor | 173 | 29(7.6) | 16(4.2) | 11(2.9) | 14(3.6) | 12(3.1) |
| Outdoor | 211 | 22(5.7) | 15(3.9) | 15(3.9) | 8(2.1) | 7(1.8) |
| $X^2$(P-val) | | 3.314(0.069) | 0.586(0.444) | 0.085(0.771) | 3.256(0.071) | 2.64(0.104) |

**Table 4:** Prevalence of Clinical and Subclinical mastitis of cows in small holder livestock production systems in and around Ambo town

| Type of mastitis | No. of animals affected | Prevalence (%) |
|---|---|---|
| Clinical | 16 | 10.7 |
| Subclinical | 48 | 32 |
| **Total** | **64** | **42.7** |

**Table 5:** Prevalence and association of mastitis of cows with breed, body condition, parity, housing and origin in and around Ambo town

| Risk factors | Risk factors Category | No. examined | No. Positive and (prevalence %) | | Total (%) | $X^2$ (P-value) | |
|---|---|---|---|---|---|---|---|
| | | | Clinical Mastitis | Sub-clinical Mastitis | | Clinical Mastitis | Sub-clinical Mastitis |
| Breed | Local | 90 | 6 (4) | 21 (14) | 27(18) | 3.8 (0.052) | 7.8 (0.005) |
| | Cross | 60 | 10 (6.7) | 27 (18) | 37 (24.7) | | |
| | Total | 150 | 16 (10.7) | 48 (32) | 64 (42.7) | | |
| Body condition | poor | 33 | 5 (3.3) | 11 (7.3) | 16 (10.7) | 0.96 (0.619) | 3.95 (0.139) |
| | Medium | 92 | 9 (6) | 25 (16.7) | 34 (22.7) | | |
| | Good | 25 | 2 (1.33) | 12 (8) | 24 (9.3) | | |
| | Total | 150 | 16 (10.7) | 48 (32) | 64 (42.7) | | |
| Parity | 1-3 calves | 108 | 10 (6.7) | 34 (22.7) | 44 (29.3) | 0.8 (0.37) | 0.048 (0.827) |
| | >3 calves | 42 | 6 (4) | 14 (9.3) | 20 (13.3) | | |
| | Total | 150 | 16 (10.7) | 48 (32) | 64 (40.7) | | |
| Housing | Indoor | 79 | 13 (8.7) | 32 (21.3) | 45 (30) | 5.87 (0.015) | 5.55 (0.018) |
| | Outdoor | 71 | 3 (2) | 16 (10.7) | 19 (12.7) | | |
| | Total | 150 | 16 (10.7) | 48 (32) | 64 (42.7) | | |
| Origin | Ambo town | 77 | 8 (5.3) | 22 (14.7) | 30 (20) | 0.098 (0.952) | 2.137 (0.343) |
| | Farisi and senkel | 40 | 4 (2.7) | 12 (8) | 16 (10.7) | | |
| | Awaro | 33 | 4 (2.7) | 14 (9.3) | 18 (12) | | |
| | Total | 150 | 16 (10.7) | 48 (32) | 64 (40.7) | | |

In this study, clinical mastitis was found to have significant association (X2= 5.87, p= 0.015) with housing conditions of the cows, where it was significantly higher (P<0.05) in indoor housed cows; while prevalence of subclinical mastitis was significantly associated (p<0.05) with breed (X2= 7.8, p= 0.005) and housing condition (X2= 5.55, p= 0.018), where it was significantly higher (P<0.05) in crossbred and indoor housed cows (Table 5).

## Discussion

In the present study 153 (40%) cows were affected by at least one of the reproductive problems except mastitis. The major reproductive problems identified were mastitis 64 (42.7%), followed by retained placenta 51 (13.3%), anestrous 31 (8.1%), repeat breeder 26 (6.8%), and abortion 22 (5.78%). In this study 10.7% and 32% of the

lactating animals were affected by clinical and subclinical mastitis, respectively. This is in close agreement with the report of Esheti and Moges (2014) in Ada'a district and Haile *et al*. (2014) in and around Hosanna who documented prevalence of 37.1% and 43.07%, respectively. But it is higher than Lemma and Kebede (2011) in and around Addis Ababa (27.2%) and Gashaw *et al*. (2011) in Jimma town (33.59%). However, it is lower than 52.5% reported by Bitew and Prasad (2011) in and around Bedelle area. These discrepancies could be attributed to differences in management systems, access to veterinary service and levels of awareness of the animal owners about reproductive problems.

The prevalence of the reproductive problems were significantly higher (X2= 18.424, P= 0.00) in medium body conditioned cows 68 (17.7%). This finding agrees with reports of high reproductive problems in medium body condition cows (18.69%) as was reported by Gashaw *et al*. (2011) in Jimma town. This might be due to high availability of clovers and legumes in the study area as feed of animals in the pastures. These plants have nutritive factors phytoestrogens (estrogenic) materials, when fed, have long been known to improve live weight gain and the efficiency of feed conversion by ruminants (National Research Council, 1959). In cattle increased ingestion of phytoestrogens owing to its anti-estrogenic, estrogenic and genotoxic effects on herbivores, it would cause reproductive problem.

The prevalence of the reproductive problems were significantly higher (X2= 7.241, p= 0.027) in 5-8 years old cows 82 (21.4%). This relatively agrees with what has been reported by Tesfaye and Shamble (2013) in Kombolcha which is high reproductive problems in 4-7 years old (44.06%) and in ≥7 year old (49.27%) cows. But it disagrees with the findings of Esheti and Moges (2014) in Ada'a district, who reported high reproductive problems in 1.5-3 years old cows (17%). This variation might be due to differences in the management of cows in various dairy production systems (Thatcher, 2010 a, b).

The prevalence of the reproductive problems was significantly higher (X2= 7.241, p= 0.027) in 1-3 calved cows 82 (21.4%) (Table2). This finding is in disagreement with the finding of Haile *et al*. (2014) in and around Hosanna who reported high reproductive problems (70.97%) in >3 calved cows. This may be that the 1st-3rd parity is the most productive phase of female cattle. This parity mostly falls in the age group between 5 and 8 years. Milk production is at a maximum up to the 3rd parity. After this it starts declining and high milk producing animals become negative in energy balance. As the poor farmers could not afford the high cost of concentrate feeds, the productive animals fail either to return to cyclicity or may develop endocrine disturbance which leads to reproductive problems (Khan *et al*., 2016). Additionally in the area due to feed shortages, cows with decreased milk production are culled and his practice leads to a low incidence of reproductive problems after the 3rd parity.

The prevalence of the reproductive problems were significantly higher (X2= 6.6, P= 0.01) in indoor housed cows 77 (20.1%). However, this finding was higher than those previously reported under intensive management practice in smallholder dairy cows (10%) in and around Awassa (Kassahun, 2003). This might be related to poor sanitation of the barn, resulting in contamination during calving, improper feeding and trauma.

The prevalence of retained placenta (13.3%) in this study is higher than 0.8%, 7.18%, 8.64% and 7.6% reported by Esheti and Moges (2014) in Ada'a district; Haile *et al*. (2014) in and around Hosanna; Bitew and Prasad (2011) in and around Bedelle; and Benti and Zewdie (2014) in Borena, respectively. However it is lower than 33.3% reported by Lemma and Kebede (2011) in and around Addis Ababa. These discrepancies could be attributed to the management practices, including feeding and breeding.

The prevalence of retained placenta were significantly higher (X2= 16.738, p= 0.00) in cows with age group of 5-8 and parity 1-3. The reproductive system of aging cows (cow with higher parity) probably involves more complex and permanent uterine changes

than those cows with lower parities. The effect of parity number on the occurrence of reproductive problems is probably due to repeated exposure of the genital tract to environmental factors which result in increased uterine infections. Longer recovery time from parturition, lactation stress and the low feed intake capacity of the older cows could also be other reasons for this variation (Hebert, *et al*., 2011).

The prevalence of anestrous in this study (8.1%) is in close agreement with 10.26% and 10.3% reported by Haile *et al*. (2014) in and around Hosanna and Hundie *et al*. (2013) in and around Horro-Guduru, respectively. But it is higher than 1.66% and 0.3% reported by Bitew and Prasad (2011) in and around Bedelle and Gashaw *et al*. (2011) in Jimma town, respectively. However it is lower than 21.1% reported by Hundie *et al*. (2013) in and around Horro-Guduru area. The prevalence of anestrous was significantly higher (X2= 17.653, p= 0.00) in poor body condition. This difference might be due to the variation in breed, nutrition and management system in these different areas. In the study area dairy cows are habitually reliant on field grazing and by-products of seasonal crops for feed. This kind of the feed stuff have low crude protein, so rumen efficiency is decreased and true digestibility of the feed also moderated.There is consequently a direct correlation between negative energy balance and a reduction in the release of gonadotropin releasing hormone (Mwaanga and Janowski, 2000). Thus indicating that nutritional deprivation decreases gonadotropin releasing hormone pulses frequency by enhancing hypothalamic inactivity.

The prevalence of repeat breeder 6.8% is higher than 3% and 1.3% reported by Bitew and Prasad (2011) in and around Bedelle and Gashaw *et al*. (2011) in Jimma town, respectively. But it was lower than 15.9% and 13.08% reported by Esheti and Moges (2014) in Ada'a district and Haile *et al*. (2014) in and around Hosanna, respectively. The prevalence of repeat breeder were significantly higher (X2= 8.411, p= 0.015) in both age (5-8) and parity (1-3). The reproductive system of aging cows (cow with higher parity) probably involves more complex and permanent uterine changes than those cows with lower parities. The effect of parity number on the occurrence of reproductive problems is probably due to repeated exposure of the genital tract to environmental factors which result in increased uterine infections. These factors may lead to endocrine disturbances leading to failure of ovulation, failure of fertilization and early embryonic death resulting in repeat breeder (Khan, *et al*., 2016).

The prevalence of abortion 5.7% in this study is similar to the 5.3% reported by Esheti and Moges (2014) in Ada'a district and 5.9% reported by Temesgen and Tegegn (2015) at Bako livestock research farm. But higher than 2.56% reported by Haile *et al*. (2014) in and around Hosanna area and lower than 13.9%, 12.2% and 22.8% by Bitew and Prasad (2011) in and around Bedelle, Benti and Zewdie (2014) in Borena and Lemma and Kebede (2011) in and around Addis Ababa, respectively. These differences might be due to management system and environmental factors as explained by Gashaw *et al*. (2011).

The prevalence of abortion was high in artificial insemination breeding. This might be due to use of untreated semen from bull infected by abortive diseases. In the area most artificial insemination was used in cross breed cattle's which are low adaptation to the tropical areas but in the present study breed was not shown to have association with reproductive problems.

The prevalence of dystocia 5% in this study were in close agreement with 5.9% and 6.64% reported by Haile *et al*. (2014) in and around Hosanna and Bitew and Prasad (2011) in and around Bedelle, respectively. But it is higher than 3.3% and 3.4% reported by Esheti and Moges (2014) in Ada'a district and Benti and Zewdie (2014) in Borena, respectively. But lower than 9.5% reported by Lemma and Kebede (2011) in and around Addis Ababa area. This variation might be due to variations in the cause of dystocia in the different studies. Dystocia can be caused by several factors such as nutritional status, age, parity and breed

(Noakes *et al*., 2002). Inseminating cows with semen collected from large sires together with the age of cows is an important risk factor in dystocia.

The prevalence of vaginal prolapse 0.8 % in this study is in close agreement with 0.66% reported by Bitew and Prasad (2011) in and around Bedelle area, but lower than 2.05% reported by Haile *et al*. (2014) in and around Hosanna. The prevalence of uterine prolapse 0.3% in this study is in close agreement with 0.76% reported by Haile *et al*. (2014) in and around Hosanna and 0.5% in Jimma town by Gashaw *et al*. (2011). But lower than 1% and 2.7% reported by Bitew and Prasad (2011) in and around Bedelle, and Benti and Zewdie (2014) in Borena respectively. The variations in the prevalence of both uterine and vaginal prolapsed in the present and other previous studies related to the variations in the causes of both uterine and vaginal prolapse in the different study areas such as hypocalcaemia, poor uterine tone, increased straining, weight of the retained fetal membrane and excessive estrogen content of the feed (Yavas and Walton 2000).

The higher prevalence of mastitis in this study 42.7% is in close agreement with 46.9% in and around Gondar town by Alemu *et al*. (2013), but higher than 35.5% reported by Moges *et al*. (2012) in Hawassa. However lower than 81.1%, 66.1% and 52.78% by Duguma *et al*. (2013) in Holleta Agricultural Research Center, Bedada and Hiko (2011) at Asella and Sori *et al*. (2005) in and around Sebeta, respectively. This variation might be due to difference in management systems, breed of animals, milking behavior with cleaning of udders and teats, implementation of regular mastitis monitoring program and hygiene of the animals.

The prevalence of clinical mastitis in this study 10.7% (Table 4) is in close agreement with 7.8%, 9.7% and 10.3% reported by Duguma *et al*. (2013) in Holleta Agricultural Research Center, Alemu *et al*. (2013) in and around Gondar town and Bedada and Hiko (2011) at Asella, respectively. But it is higher than 4.9% reported by Moges et al. (2012) in Hawassa. However, it was lower than 19.3% and 16.11% reported by Tesfaye and Shamble (2013) in Kombolcha and Sori *et al*. (2005) in and around Sebeta, respectively. This variation might be due to differences in management systems, breed of animals, milking behavior with cleaning of udders and teats and hygiene of the animals. With regard to mastitis, clinical mastitis had significant relationship with indoor housing (X2= 5.87, p= 0.015). This might be related to poor sanitation of the barn, resulting in contamination of the teat, improper hygiene and trauma of the udder.

The prevalence of subclinical mastitis in this study 32% is in close agreement with 37.2%, 30.6% and 36.67% reported by Alemu *et al*. (2013) in and around Gondar town, Moges *et al*. (2012) in Hawassa and Sori *et al*. (2005) in and around Sebeta areas, respectively. But it is lower than 73.3% and 55.8% reported by Duguma *et al*. (2013) in Holleta Agricultural Research Center and Bedada and Hiko (2011) at Asella areas, respectively. Subclinical mastitis had significant relationship with indoor housing (X2= 5.87, p= 0.015) and breed (X2= 7.8, p= 0.005). This might be related to poor sanitation of the barn, resulting in contamination of the teat, improper hygiene and trauma of the udder.

The dominance of sub-clinical mastitis in this study is most likely attributed to the little attention paid by the farmers to sub-clinical mastitis, as the infected animals does not exhibit any clinical symptom and secrets apparently "normal" milk. Lack of implementation of regular mastitis monitoring program such as California mastitis test (CMT) or other testing methods by all of the farmers also could contribute to the observed high prevalence of sub-clinical mastitis in the study area. Perhaps this fact may justify the lack of awareness on the invisible losses from sub-clinical mastitis.

## Conclusion and Recommendations

In this study area the major reproductive problems encountered were mastitis, retained placenta, anestrous, repeat breeder, abortion, dystocia, vaginal prolapse and uterine prolapse. These problems could create major impediments in the smallholder dairy farming

and hence need interventions at different levels including awareness creation among animal owners on appropriate management of the problems. Furthermore, epidemiological studies with isolation of pathogenic organisms in milk and associated risk factors should be conducted to enable the development of appropriate intervention packages.

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# COMBINATION OF TRACE MINERAL CHELATES WITH B-VITAMINS ACT IN SYNERGY TO IMPROVE FEED UTILISATION AND HAEMATOLOGY IN TURKEYS

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## Abstract

This study was conducted to evaluate the growth, nutrient digestibility, energy metabolisability and selected haematological indices in growing turkeys fed diets containing inorganic or chelated blends of Cu, Zn and Mn with or without supplements of riboflavin (B2) and pyridoxine (B6). Three hundred and twenty, 4-week old British United Turkey toms were assigned to 8 dietary treatments in a 2 × 4 factorial arrangement comprising 2 trace mineral sources: Chelated trace mineral blend (CTMB) and its corresponding Inorganic trace minerals blend (ITMB), fed solely or with supplements of vitamins B2 (8 mg/kg) or B6 (7 mg/kg) or 8 mg/kg 1 B2 + 7 mg/kg B6 The feeding experiment lasted for 12-weeks.. Higher ($P<0.05$) energy metabolism, Packed Cell Volume, Haemoglobin concentration and red blood cell counts were recorded in young and growing turkeys fed diets containing CTMB with supplements of riboflavin or pyridoxine than those of their counterparts fed diets without supplements of vitamins. However, the reverse was the case in turkeys fed ITMB-supplemented diets. Growth of turkeys was not affected ($P>0.05$) by dietary treatments. In conclusion, combination of chelated Cu, Zn and Mn with vitamins B2 and/or B6 tended to act in synergy for improved feed utilisation and haematological indices in growing turkeys.

**Key words:** Copper, zinc, manganese, riboflavin, pyridoxine, Nutrient utilisation

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## Introduction

Trace elements such as coppper, zinc, manganese and B-vitamins are required in very small quantities in livestock animals however, their roles in important metabolic reactions in the body cannot be downplayed. The most important aspect impacting the benefit of trace elements to the animals is 'bioavailability' which is the amount of an ingested element that the animal is able to digest, absorb, and use for some metabolic function (O'Dell, 1997). According to Jongbloed *et al*., (2002) factors such as source of trace minerals (inorganic or organic), ratio between various individual minerals, vitamin levels, anti-nutrients factors can have great impact on the bioavailability of trace minerals.

Mineral chelates are made up of trace elements bonded with biological /organic material like protein primers or amino acids like methionine which aid their easy cleavage, absorption and subsequent utilization when ingested in feed for farm animals (Nollet et al., 2007). inorganic salts on the other hand dissociate into very reactive ions in the gut hence subject to many negative reactions that impair their availability, Hence the superiority of mineral chelates to inorganic salts regarding improvement the performance of farm animals (Jegede *et al*., 2011; El-Husseiny *et al*., 2014)

Vitamins (particularly those of the B-group) are closely associated with the metabolic functions of minerals and can exert antagonistic or synergistic effects on the bioavailability and utilization of trace minerals (Watt, 1990; Idowu *et al*., 2011).Therefore this study seeks to determine the performance, nutrient digestibility, metabolic energy values and selected haematological parameters in growing turkeys fed diets containing inorganic or chelated blends of Cu, Zn and Mn with or without supplements of riboflavin (B2) and pyridoxine (B6).

## Materials and methods

The inorganic salts used to form ITMB consisted of feed grade copper sulphate pentahydrate (CuSO4.7H2O; containing 25% Cu), zinc oxide (ZnO; containing 72% Zn) and manganese dioxide (MnO2; containing 64% Mn) supplying Cu, Zn and Mn, repectively. Commercially sourced (Novus Inc, St Louis, USA) chelated trace mineral blend of Mintrex® (CTMB; containing 16% Cu, 15% Zn and 13% Mn, respectively) was used to supply Cu, Zn and Mn. Pharmaceutical grade riboflavin phosphate (containing 3 mg pure riboflavin (vitamin B2) per tablet) and Pyridoxine hydrochloride (with a purity of 82.27% pyridoxine (vitamin B6)) were used to supply riboflavin and pyridoxine in this study.

A total of three hundred and twenty (320), 28 days-old, British United Turkey (BUT) toms were allotted (on weight equalisation basis) to 8 dietary treatments in a 2 × 4 factorial arrangement of experimental diets containing; 2 sources of trace mineral blends (CTMB or ITMB), each having either no vitamin additive (control), vitamin B2 at 8 mg/kg), vitamin B6 (at 7 mg/ kg) or combination of vitamin B2 (at 8 mg/kg) and B6 (at 7 mg/ kg) (i.e. vitamin B2 + B6) . Each treatment was replicated four times with 10 turkeys each. The inclusion levels of mineral blends (CTMB) in diets were based on the manufacturer's reccomendations i.e. 1000 mg/ kg (supplying 1.20, 5.12 and 4.16 mg/ kg of Cu, Zn and Mn, respectively). The CTMB was in fine crystalline form and predetermined weights were added during ration compounding when they were mixed to form respective homogenous experimental composite feeds. Thereafter, inorganic salt blends were also formulated to supply same amounts of Cu, Zn and Mn. Appropiate weights of respective inorganic salts (in crystalline form) that supplied corresponding concentrations of Cu, Zn and Mn were thoroughly mixed together in separate bowls to form a uniform blend (ITMB) which were then incorporated with already milled (1.0 mm sieve) other bulk ingredients and mixed thoroughly again in a motorised mixer until a homogenous composite feed in mash form was achieved. These levels of inclusion were maintained throughout for all the growth phases of the turkeys. Other feed stuff ingredients in the basal diets were

formulated to meet the nutrient requirements of starting and growing turkeys (NRC, 1994) (Table 1).

At the end of 12-week feeding trial 2 turkeys (16 weeks of age) were randomly selected from each replicate (8 birds per treatment, 64 birds in all) and placed in individual metabolic cages complete with seperate feeders and plastic trays for total excreta collection (Bourdillon *et al*., 1990). Following a 3-day acclimatisation period, the birds were fed with weighed quantities of respective experimental diets for 4 days. Total excreta voided per bird during 4 days collection period was pooled. Representative samples collected from feed and total excreta voided per bird per replicate were milled (0.1mm sieve), weighed and oven dried at 65 °C for 48 hours and subjected to proximate analysis AOAC (2005).Apparent nutrient digestibility of the various nutrients were calculated

Another group of birds (2 turkeys randomly selected from each replicate (8 birds per treatment, 64 birds in all) were moved into metabolic cages for energy metabolisability trial. The birds were fasted for 24 hours and only administered water for another 24 hours. At the lapse of 24 hours, excreta was collected weighed, oven dried at 65 °C and weighed again. The samples of the excreta for respective groups were pooled, milled (0.1 mm sieve) and assayed for gross energy according to Sibbald (1980). The apparent and true metabolizable energy, apparent and true metabolizable energy Corrected for Nitrogen Retention (AMEn) were calculated using appropriate formulae.

About 2.5ml of blood samples were obtained from the brachial vein of each of 2 turkeys per replicate (8 birds per treatment, 64 birds in all) when the birds were 8 and 16 weeks old, respectively. The blood samples were collected into individual sterilized ethylene diamine tetra acetate (EDTA) tubes, plasma was harvested subsequently by centrifuging at 3000 rpm for 15 min. Measurement of packed cell volume (PCV), red blood cell (RBC) count and white blood cell (WBC) count were done as described by (Schalm *et al*.,1975). Data obtained in this experiment was laid out in a 2 × 4 factorial arrangement, subjected to Analysis of Variance (Steel and Torrie, 1980) and analysed using SAS (2010) to determine main and interaction effects. Level of probability was expressed at 5% and significant means seperated using Duncan multiple range test (Duncan, 1955).

## Results

Table 2 shows the result on the main and interaction effects of trace minerals source and vitamin-B. Turkey poults fed diets containing CTMB had lower ($P<0.05$) feed intake and improved ($P<0.05$) FCR compared to their counterparts fed diets containing ITMB. Vitamin-B supplementation however did not affect ($P>0.05$) the growth indices measured. The interaction effect of trace mineral source and vitamin-B supplementation was not signifcant on the growth of young turkeys (5-8 weeks old) and growing turkeys (9-16 weeks old).

Nutrient utilisation in 16 week old turkeys fed diets containing different ITMB and CTMB with or without supplements of vitamin B are displayed on Table 3. Turkeys fed diets containing CTMB with supplement of B2 had the highest ($P>0.05$) values for DM, CP, ash and NFE digestibility while birds fed diets supplemented solely with ITMB had the least ($P>0.05$) values. Significant improvement in energy metabolisability was observed in turkeys fed diets containing CTMB with supplements of vitamins B2 and/ or B6. However turkeys fed diets supplemented with ITMB + B2 + B6 showed decreased ($P<0.05$) AME. Turkeys fed CTMB+B2 supplemented diets had the highest ($p>0.05$) TME and TMEn values which were 13.26 and 13.18 MJ kg-1 respectively while least ($P>0.05$) values (11.92 and 11.82 MJ kg-1 respectively) were observed in turkeys fed diet supplemented solely with CTMB.

Table 4 shows the main and interaction effects of trace mineral source and vitamin-B supplementation on the haematological measurements in young (5-8 weeks old) and growing (9-16 weeks old). There were no differences ($P>0.05$) in the haematological

**Table I:** Basal composition of turkeys diets (g/kg)

| Item | Starter diet (5 to 8 weeks of age ) | Grower diet (9-16 weeks of age ) |
|---|---|---|
| Maize | 442.00 | 553.00 |
| Fish meal(72% CP) | 80.00 | 60.00 |
| Soy bean meal | 355.00 | 284.00 |
| Wheat offal | 50.00 | 40.00 |
| Bone meal | 33.00 | 27.00 |
| Limestone | 24.00 | 15.00 |
| Lysine | 1.50 | 1.50 |
| Methionine | 2.00 | 2.00 |
| Vit/Trace Min. Premix | 5.00 | 5.00 |
| Common Salt | 2.50 | 2.50 |
| Palm Oil | 5.00 | 10.00 |
| Total | 1000.00 | 1000.00 |
| **Determined analysis** | | |
| Metabolisable Energy (Kcal/kg) | 2845.04 | 3017.11 |
| Crude Protein (g/kg) | 250.60 | 214. 80 |
| Crude Fat ( g/kg)) | 44. 80 | 49.80 |
| Crude Fibre ( g/kg) | 31.70 | 34.00 |
| Ash ( g/kg) | 24.20 | 17. 90 |
| Basal diet Cu (mg/kg) | 31.58 | 30.44 |
| Basal diet Zn (mg/kg) | 51.27 | 51.38 |
| Basal diet Mn (mg/kg) | 56.83 | 51.83 |

**Vitamin -Trace mineral composition based on 5.0g premix per kg of feed*
*Turkey grower premix composition per Kg diet: vit A: 40, 000IU, vit D3: 4000IU, vit E: 40.0 mg, vit K3: 8mg, vit B1: 1.0mg, vit B2: 8mg, vit B6: 5mg, vit B12: 0.025mg, Niacin: 60mg, Panthothenic acid: 20mg, Folic acid: 2000mg, Biotin: 150mg, , Iron: 32mg, Cobalt: 80mg, Iodine:0.15mg, Selenium: 0.2mg, Choline: 300mg*

indices measured in young turkeys fed diets containing CTMB and ITMB. However, vitamin B6 supplementation resulted in significant improvement in the concentrations of PCV, HB and RBC over those of the control. The interaction effects of trace mineral source and vitamin B supplementation was significant (P<0.05) on all haematological parameters measured. Combination of CTMB with B6 led to significant improvement (P<0.05) in the values of PCV, HB and RBC over those of the control. However a reverse trend (P<0.05) was observed in the values of PCV and HB with the combination of ITMB with B2 +B6.

Growing turkeys fed ITMB supplemented diet elicited higher (P<0.05) RBC while those fed vitamin B6 supplemented diets showed the highest (P<0.05) PCV, RBC and WBC values over those on other dietary treatments.The interaction effects of trace mineral source and vitamin supplementation was significant (P<0.05) on PCV, RBC and WBC. Vitamin combination with ITMB led to a reduction (p<0.05) in the values of PCV in turkeys fed supplemented diet. The RBC value in turkeys fed CTMB supplemented diet increased (p<0.05) following supplementation with vitamin B6 while the combination of ITMB with vitamins B2 and or B6 led to a reduction (P<0.05) in values. Highest (P<0.05) WBC value (24.57 x 103/ mm3) was observed in turkeys fed CTMB+B6 supplemented diet while least (P<0.05) values

**Table II:** Effects of trace mineral sources and vitamin B supplementation on growth performance of young (5-8 weeks) and growing (9-16 weeks) turkeys

| | | Young turkeys (5-8 weeks) | | | | Growing turkeys (9-16 weeks) | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Mineral source** | **Vitamin $B_2$ or $B_6$** | **Final wt (g)** | **Total wt. gain (g)** | **Totalfeed int. (g)** | **FCR** | **Final wt (g)** | **Totalwt. gain (g)** | **Total feed int. (g)** | **FCR** |
| Main effects | | | | | | | | | |
| ITMB | | 3878.33 | 2308.00 | 5386.70b | 2.31[b] | 10480.00 | 6440.00 | 22520.00 | 3.50[a] |
| CTMB | | 3891.67 | 2318.00 | 5905.00a | 2.55[a] | 10610.00 | 6457.00 | 20170.00 | 3.12[b] |
| | None | 3802.00 | 2266.67 | 5641.70 | 2.51 | 10610.00 | 6536.00 | 21800.00[ab] | 3.34[b] |
| | $B_2$ | 3887.00 | 2326.67 | 5703.30 | 2.47 | 10710.00 | 6620.00 | 19450.00[b] | 2.94[c] |
| | $B_6$ | 3903.00 | 2373.33 | 5476.70 | 2.34 | 10050.00 | 5950.00 | 22940.00[a] | 3.86[a] |
| | $B_2$+$B_6$ | 3947.00 | 2306.67 | 5761.70 | 2.45 | 10820.00 | 6697.00 | 21194.00[ab] | 3.17[c] |
| Interaction | | | | | | | | | |
| ITMB | none | 3773.33 | 2206.67 | 5173.33 | 2.33 | 10800.00 | 6746.00 | 22500.00[a] | 3.34[ab] |
| ITMB | $B_2$ | 3873.33 | 2293.33 | 5660.00 | 2.47 | 10500.00 | 6493.33 | 23600.00[a] | 3.63[a] |
| ITMB | $B_6$ | 3860.00 | 2300.00 | 5286.67 | 2.30 | 10100.00 | 6066.00 | 22100.00[a] | 3.64[a] |
| ITMB | $B_2$+$B_6$ | 4006.67 | 2433.33 | 5426.67 | 2.25 | 10600.00 | 6573.33 | 21900.00[a] | 3.98[ab] |
| CTMB | $B_0$ | 3833.33 | 2266.67 | 6110.00 | 2.69 | 10100.00 | 6080.00 | 21100.00[a] | 3.60[a] |
| CTMB | $B_2$ | 3900.00 | 2326.67 | 5746.67 | 2.47 | 10300.00 | 6260.00 | 16600.00[b] | 2.65[b] |
| CTMB | $B_6$ | 3946.67 | 2373.33 | 5666.67 | 2.39 | 9374.67 | 5368.00 | 21800.00[a] | 4.06[a] |
| CTMB | $B_2$+$B_6$ | 3885.00 | 2306.67 | 6096.67 | 2.64 | 9725.00 | 5705.00 | 19800.00[b] | 3.47[a] |
| SEM | | | | | | | | | |
| Mineral Source | | 48.18 | 45.91 | 183.39 | 0.07 | 31.57 | 30.15 | 127.08 | 0.05 |
| Vitamin B | | 68.13 | 30.15 | 127.08 | 0.14 | 283.12 | 288.41 | 738.99 | 0.14 |
| Source × vitamin | | 31.57 | 30.15 | 127.08 | 0.05 | 20.00 | 180.45 | 176.50 | 581.65 |
| P-values | | | | | | | | | |
| Mineral | | 0.722 | 0.847 | 0.88 | 0.006 | 0.882 | 0.796 | 0.786 | 0.542 |
| Vitamin B | | | | | | | | | |
| Supplementation | | 0.759 | 0.524 | 0.786 | 0.878 | 0.717 | 0.257 | 0.318 | 0.182 |
| Source × vitamin | | 0.796 | 0.786 | 0.542 | 0.312 | 0.140 | 0.340 | 0.605 | 0.695 |

[abcd]*:Means along the same column with different superscripts are significantly different (p<0.05). SEM, Standard Error of Mean*
*CTMB,Chelated trace mineral blend; ITMB, Inorganic trace mineral blend; Int , intake; wt, weight; FCR; Feed Conversion ratio*

**Table III:** Effects of trace mineral source and vitamin B supplementation on apparent nutrient digestibility and energy metabolisability at 12 weeks of age

| Mineral source | Vitamin $B_2$ or $B_6$ | Nutrient digestibility(%) | | | | | Energy metabolisability (MJ/Kcal) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Dry matter | Crude protein | Ether extract | Crude fibre | Ash | NFE | AME | AMEn | TME | TMEn |
| Main effects | | | | | | | | | | | |
| ITMB | | 76.91 | 88.09 | 78.26 | 58.06 | 71.03 | 81.69 | 11.68 | 11.59 | 12.80 | 12.72 |
| CTMB | | 74.61 | 86.64 | 76.64 | 64.13 | 67.07 | 79.95 | 11.44 | 11.33 | 12.48 | 12.39 |
| | None | 73.12 | 85.44 | 74.19 | 61.35 | 66.55 | 78.62 | 11.19$^{b}$ | 11.11$^{b}$ | 12.35 | 12.26 |
| | $B_2$ | 76.13 | 87.91 | 78.88 | 60.73 | 70.37 | 81.28 | 12.14$^{a}$ | 12.06$^{a}$ | 13.04 | 12.95 |
| | $B_6$ | 74.72 | 86.94 | 76.34 | 62.81 | 66.78 | 79.83 | 11.87$^{ab}$ | 11.79$^{ab}$ | 12.70 | 12.62 |
| | $B_2$+$B_6$ | 79.07 | 89.16 | 80.39 | 59.5 | 72.51 | 83.56 | 10.97$^{b}$ | 10.89$^{ab}$ | 12.47 | 12.38 |
| Interaction | | | | | | | | | | | |
| ITMB | none | 74.49 | 86.26ab | 77.24ab | 52.6 | 70.44 | 79.44 | 10.35$^{bc}$ | 10.27$^{bc}$ | 11.92$^{c}$ | 11.83$^{b}$ |
| ITMB | $B_2$ | 80.34 | 90.12a | 81.97a | 63.11 | 75.05 | 84.38 | 12.19$^{a}$ | 12.10$^{a}$ | 13.26$^{a}$ | 13.18$^{a}$ |
| ITMB | $B_6$ | 75.2 | 87.60ab | 75.86ab | 60.48 | 67.78 | 80.2 | 12.23$^{a}$ | 12.18$^{a}$ | 13.10$^{ab}$ | 13.02$^{a}$ |
| ITMB | $B_2$+$B_6$ | 77.59 | 88.36ab | 77.99ab | 56.49 | 70.84 | 82.75 | 11.90$^{a}$ | 11.81$^{a}$ | 12.92$^{abc}$ | 12.84$^{ab}$ |
| CTMB | $B_0$ | 71.74 | 84.61b | 71.13b | 70.1 | 62.65 | 77.79 | 12.04$^{a}$ | 11.95$^{a}$ | 12.77$^{abc}$ | 12.69$^{ab}$ |
| CTMB | $B_2$ | 71.91 | 85.69ab | 75.80ab | 58.33 | 65.68 | 78.17 | 12.10$^{a}$ | 12.02$^{a}$ | 12.81$^{abc}$ | 12.73$^{ab}$ |
| CTMB | $B_6$ | 74.23 | 86.28ab | 76.82ab | 65.57 | 65.79 | 79.46 | 11.47$^{ab}$ | 11.39$^{ab}$ | 12.31$^{abc}$ | 12.22$^{ab}$ |
| CTMB | $B_2$+$B_6$ | 80.54 | 89.96a | 82.80a | 62.51 | 74.17 | 84.37 | 10.04$^{c}$ | 10.00$^{c}$ | 12.02$^{bc}$ | 11.93$^{b}$ |
| SEM | | | | | | | | | | | |
| Mineral Source | | 1.37 | 0.68 | 1.27 | 3.07 | 1.88 | 1.11 | 0.21 | 0.21 | 0.16 | 0.16 |
| Vitamin B | | 1.94 | 0.96 | 1.79 | 4.35 | 2.67 | 1.56 | 0.42 | 0.3 | 0.23 | 0.23 |
| Source × vitamin | | 1.05 | 0.56 | 1.04 | 2.1 | 1.4 | 1.89 | 0.21 | 0.21 | 0.14 | 0.14 |
| P-values | | | | | | | | | | | |
| Mineral | | 0.252 | 0.15 | 0.378 | 0.182 | 0.157 | 0.281 | 0.392 | 0.39 | 0.181 | 0.179 |
| Vitamin B | | | | | | | | | | | |
| Supplementation | | 0.206 | 0.082 | 0.112 | 0.959 | 0.349 | 0.179 | 0.043 | 0.042 | 0.199 | 0.197 |
| Source ×vitamin | | 0.91 | 0.88 | 0.86 | 0.27 | 0.49 | 0.97 | 0.005 | 0.005 | 0.057 | 0.056 |

*$^{abcd}$:Means along the same column with different superscripts are significantly different ($p<0.05$). SEM, Standard Error of Mean; CTMB, Chelated trace mineral blend; ITMB, Inorganic trace mineral blend; ITMB, Inorganic trace mineral blend: B0, no ; supplemental vitamin; NFE, Nitrogen free extract; AME, apparent metabolisable energy; AMEn, apparent metabolisable energy corrected for nitrogen retention; TME, True metabolisable energy ; TMEn, True metabolisable energy corrected for nitro gen retention*

**Table IV:** Effects of trace mineral sources and vitamin B supplementation on haematological indices in young (at 8weeks) and growing (at 16 weeks) turkeys

| | | Young turkeys (8 weeks old) | | | | Growing turkeys (16 weeks old) | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Mineral source** | **Vitamin $B_2$ or $B_6$** | **PCV (%)** | **HB (g $d^{-1}$)** | **RBC (x$10^6$/ $mm^3$)** | **WBC (x$10^3$/ $mm^3$)** | **PCV (%)** | **HB (g $dl^{-1}$)** | **RBC (x$10^6$/ $mm^3$)** | **WBC (x$10^3$/ $mm^3$)** |
| Main effects | | | | | | | | | |
| ITMB | | 35.94 | 11.98 | 6.64 | 25.2 | 43.04 | 14.7 | 2.60b | 20.22 |
| CTMB | | 36.88 | 12.29 | 6.95 | 26.28 | 42.8 | 12.88 | 3.00 b | 20.51 |
| | None | $36.83^{b}$ | $12.28^{b}$ | $6.89^{ab}$ | $26.16^{ab}$ | 43.50b | 14.44 | 2.88 b | $20.20^{b}$ |
| | $B_2$ | $36.17^{b}$ | $12.06^{b}$ | $6.60^{b}$ | $24.72^{ab}$ | $43.01^{b}$ | 14.95 | 2.55 c | $19.72^{b}$ |
| | $B_6$ | $43.29^{a}$ | $14.43^{a}$ | $7.28^{a}$ | $28.43^{a}$ | $48.50^{a}$ | 14.72 | 3.20 a | $23.73^{a}$ |
| | $B_2$+$B_6$ | $29.33^{c}$ | $9.78^{c}$ | $6.40^{b}$ | $23.64^{b}$ | $36.59^{c}$ | 11.03 | 2.50 c | $17.81^{c}$ |
| Interaction | | | | | | | | | |
| ITMB | none | $30.50^{cd}$ | $9.93^{cd}$ | $2.78^{ab}$ | $24.40^{ab}$ | $37.00^{ef}$ | $13.30^{ab}$ | $2.62^{d}$ | $18.41^{de}$ |
| ITMB | $B_2$ | $36.00^{bcd}$ | $11.17^{bcd}$ | $2.21^{b}$ | $24.17^{ab}$ | $46.02^{c}$ | $15.34^{a}$ | $2.30^{e}$ | $20.23^{c}$ |
| ITMB | $B_6$ | $49.07^{a}$ | $16.00^{a}$ | $3.51^{a}$ | $25.50^{ab}$ | $54.00^{a}$ | $18.00^{a}$ | $3.40^{a}$ | $24.57^{a}$ |
| ITMB | $B_2$+$B_6$ | $28.17^{d}$ | $9.13^{d}$ | $2.04^{b}$ | $22.60^{b}$ | $35.00^{f}$ | $11.30^{b}$ | $2.07^{e}$ | $17.67^{e}$ |
| CTMB | $B_0$ | $43.17^{ab}$ | $14.33^{ab}$ | $3.00^{a}$ | $25.00^{ab}$ | $50.00^{b}$ | $15.53^{a}$ | $3.13^{b}$ | $22.00^{b}$ |
| CTMB | $B_2$ | $36.33^{bcd}$ | $11.67^{bcd}$ | $3.00^{a}$ | $25.23^{ab}$ | $40.00^{de}$ | $13.63^{ab}$ | $2.80^{cd}$ | $19.20^{cd}$ |
| CTMB | $B_6$ | $37.50^{bc}$ | $12.33^{bc}$ | $3.04^{a}$ | $25.27^{ab}$ | $43.00^{cd}$ | $13.53^{ab}$ | $3.00^{bc}$ | $22.90^{b}$ |
| CTMB | $B_2$+$B_6$ | $30.50^{cd}$ | $9.87^{cd}$ | $2.76^{ab}$ | $24.67^{ab}$ | $38.17^{ef}$ | $12.72^{b}$ | $2.93^{bc}$ | $17.95^{de}$ |
| SEM | | | | | | | | | |
| Mineral Source | | 2.92 | 0.46 | 0.21 | 0.99 | 2.36 | 0.79 | 0.15 | 0.84 |
| Vitamin B | | 1.95 | 0.65 | 0.17 | 1.34 | 0.9 | 1.4 | 0.06 | 0.31 |
| Source × vitamin | | 1.59 | 0.52 | 0.12 | 0.72 | 1.35 | 0.74 | 0.089 | 0.51 |
| P-values | | | | | | | | | |
| Mineral | | 0.64 | 0.64 | 0.08 | 0.434 | 0.817 | 0.211 | 0.000 | 0.360 |
| Vitamin B | | | | | | | | | |
| Supplementation | | 0.001 | 0.001 | 0.01 | 0.106 | 0.000 | 0.197 | 0.000 | 0.000 |
| Source×vitamin | | 0.01 | 0.01 | 0.01 | 0.001 | 0.000 | 0.000 | 0.256 | 0.000 |

*[abcd]: Means along the same column with different superscripts are sigmificantly different (P<0.05). SEM , Standard Error of Mean*

*CTMB= Chelated trace mineral blend, ITMB =Inorganic trace mineral blend, PCV =Packed cell volume, Hb = Haemoglobin, RBC = Red blood cell WBC = White blood cell*

(17.67 and 17.95 x 103/mm3) were observed in turkeys fed diets supplemented with CTMB+ B2 + B6 and ITMB+ B2 + B6 respectively.

## Discussion

In the present study, growth performance of young turkeys fed vitamin-trace mineral supplemented diets were not affected by dietary treatments. However, improved feed conversion observed in turkeys fed diets containing CTMB with or without vitamin-B supplement in comparison to those of ITMB group could be attributed to highly bioavailable Cu, Zn, Mn from mineral chelates and the synergistic effect of vitamin B6, B2 in enzyme systems that helps to boost feed utilisation (Dayanandan *et al*., 2001: Derin *et al*., 2006). Riboflavin serves as co-enzyme in many metabolic pathways and is also necessary for the metabolism of vitamin B6. Thus the reduced feed intake and improved feed conversion ratio observed in growing turkeys fed diets supplemented with ITMB+B2 compared to those of other treatment groups in this study may be attributed to the effect of riboflavin on the basal metabolic rate of turkeys. These observations therefore suggests a synergistic relationship exists between riboflavin and inorganic trace minerals.

Higher apparent CP and ether extract digestibility observed in turkeys fed diets containing CTMB with supplements of vitamin B2 and ITMB with B2+B6 and improved the energy metabolisability in those CTMB+B2 supplemented diets may be attributed to the ubiquitous role of riboflavin in the metabolism of macro and micronutrients particularly energy yielding metabolism (Cooperman and Lopez, 1984). Folate and pyridoxine are vitamins that rely on riboflavin for activation and this may have contributed to improved utilisation of nutrient in turkeys fed ITMB+B2+B6 supplemented diets.

All blood parameters measured in this study (except PCV) fell within the range reported by Feldman *et al*., (2000) for normal chickens. Elevated PCV values observed in turkeys fed diets supplemented with CTMB+B6 and ITMB may be an indication of high oxygen carrying capacity of the cells in this group of turkeys. The observed improvement in the concentration of PCV, HB and RBC in turkeys fed combination of pyridoxine with trace mineral blend may be attributed to the role of pyridoxine and Cu in synthesis of haemoglobin and the formation of red blood cells (Sunders *et al*., 2012).

The study thus showed that combination of Vitamin B2 and B6 with chelated Cu, Zn, and Mn had synergistic effect on energy metabolizability and selected haematological parameters in growing turkeys however, an antagonistic effect may be produced following combination of vitamins with the inorganic forms of these trace minerals

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## Public Brief

This research demonstrated that a synergistic relationship exists between commercial trace mineral blends (Copper, zinc and Manganese provided in chelated forms) and B-vitamins (riboflavin and pyridoxine) and their interaction improves nutrient utilisation and performance of growing turkeys. Therefore the replacement of inorganic salts with mineral chelates and their combination in the diet of growing turkeys is strongly advocated for.

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# MARCHÉ DES MÉDICAMENTS VÉTÉRINAIRES AU CAMEROUN : RÉGLEMENTATION, ORGANISATION ET CIRCUITS DE DISTRIBUTION

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## Résumé

Le développement de l'élevage passe par la lutte contre les différentes maladies animales. Pour cela, la réglementation du secteur pharmaceutique et l'assurance qualité du médicament constituent des atouts considérables. Cette étude avait pour objectif d'analyser la réglementation et l'organisation du marché des médicaments vétérinaires au Cameroun. La méthodologie a consisté d'une part, en un entretien direct avec les responsables des services étatiques en charge de la pharmacie vétérinaire et d'autre part en une enquête auprès des professionnels de la filière du médicament vétérinaire. Ainsi, un échantillon de 31 acteurs a été enquêté. Les informations recherchées portaient sur les textes juridiques en vigueur sur la pharmacie vétérinaire et la distribution des médicaments vétérinaires.

Il en ressort que la pharmacie vétérinaire est réglementée par onze textes juridiques (deux accords internationaux, un accord sous régional, 3 lois, 3 décrets et deux arrêtés). En ce qui concerne le circuit de distribution du médicament, les investigations ont montré l'existence de deux circuits fonctionnant de manière parallèle. Les acteurs impliqués dans le circuit officiel sont les grossistes répartiteurs, les distributeurs détaillants, les représentants des firmes pharmaceutiques et les groupements d'éleveurs. 97 % des approvisionnements proviennent des importations. Sur le territoire, 23 structures assurent l'importation et 45 la répartition du médicament vétérinaire. Tous les grossistes répartiteurs distribuent en gros, demi-gros et au détail et 34% des détaillants importent directement leurs produits. Les médicaments les plus importés sont les antiparasitaires (54%) suivis des antibiotiques (23%). Parallèlement au dispositif officiel de distribution du médicament le circuit illicite constitue un marché concurrentiel non négligeable. L'organisation et la structuration du secteur de la pharmacie vétérinaire sont des préalables pour la mise en place d'un système d'élevage rentable, capable de répondre aux besoins des populations et d'être au service du développement.

**Mots clés :** Médicaments vétérinaires, réglementation, Distribution, Cameroun

## Abstract

The development of animal husbandry involves the fight against various animal diseases. As such, the regulation of the pharmaceutical sector and the quality assurance of veterinary drugs constitute important assets. Therefore, this study aims at analyzing the regulation and organization of the market for veterinary drugs in Cameroon. The methodology consisted, on one hand, in a direct interview of the heads of the State services in charge of veterinary pharmacy and, on the other hand, in a survey of professionals in the veterinary medicinal product market chain. Thus, a sample of 31 actors was investigated. Data collected was

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related to the existing legal framework on veterinary pharmacy and distribution of veterinary medicines. AS results, the veterinary pharmacy is regulated by eleven legal texts (two international convention, one regional convention, 3 laws, 3 decrees and two ministerial orders. Concerning drug distribution channels, investigations have shown the existence of two channels operating in parallel. The actors involved in the official channels are wholesalers, retailers, pharmaceutical companies' delegates and breeders' groups. 97% of supplies come from imports. In the territory, 23 companies ensure the importation and 45 the distribution of veterinary medicines. All wholesalers distribute wholesale, semi-wholesale and retail while 34% of retailers directly import their products. The most imported drugs are antiparasitics (54%) followed by antibiotics (23%). Parallel to the official distribution of veterinary medicines there is an illicit channel. The later significantly compete the former. The organization and structuring of the veterinary pharmacy sector are prerequisites for the establishment of a profitable livestock system capable of meeting the needs of the population and being at the service of development.

**Keywords:** Veterinary drugs, regulation, Distribution, Cameroon

## Introduction

Le Cameroun est un carrefour incontournable de l'élevage en Afrique centrale en raison de la diversité de son cheptel et des conditions favorables de productions animales dont il bénéficie (Ndottiwa, 2008). Chaque région est caractérisée par sa spécificité épidémiologique en rapport avec le type d'élevage pratiqué. Le volume de vente des médicaments vétérinaires présente une variation en fonction des zones et espèces animales (Ndottiwa, 2008). Cependant, le marché du médicament vétérinaire au Cameroun est lourdement entravé par la présence de marchés parallèles (Têko-agbo *et al*., 2009 ; Malmal, 2012). Selon les estimations de la Fédération Internationale pour la Santé Animale, la valeur du marché officiel des médicaments vétérinaires en Afrique avoisine les 400 millions de dollars soit près de 209 milliards de FCFA par an. Le commerce des médicaments non conformes et non homologués est pratiquement du même ordre. Au Cameroun, le marché des médicaments vétérinaires est estimé selon Hamadou et Banipe (2001) à environ 20 milliards de FCFA. Selon les mêmes auteurs, les opérateurs officiellement reconnus couvrent à peine la moitié de ce chiffre d'affaire montrant ainsi l'importance du marché parallèle des médicaments vétérinaires le plus souvent tenu par les non professionnels.

Vu l'ampleur du circuit parallèle du médicament vétérinaire et son impact sur la santé publique, les options stratégiques d'assainissement du marché sont nécessaires. Ainsi, pour répondre à cet épineux problème de la distribution du médicament vétérinaire au Cameroun, il serait important d'analyser la réglementation et l'organisation du marché des médicaments vétérinaires au Cameroun.

## Méthodologie

La présente étude s'est déroulée entre Avril 2015 et Septembre 2016. La méthodologie a consisté d'une part, en un entretien direct avec les responsables des services étatiques (responsable de la Sous-direction de la pharmacie vétérinaire et du secteur privé, Délégués régionaux du Ministère de l'Elevage des Pêches et des Industries Animales, Ordre National des Médecins Vétérinaires du Cameroun (ONVC)) en charge de la pharmacie vétérinaire afin de recueillir des informations sur les textes juridiques en vigueur sur la pharmacie vétérinaire et d'autre part en une enquête transversale par questionnaire complétée par des interviews directes des professionnels de la filière du médicament vétérinaire au Cameroun (importateurs-répartiteurs et les détaillants de médicament vétérinaire, syndicat des importateurs de médicament vétérinaire, Ordre National des Médecins Vétérinaires du Cameroun). Pour circonscrire ces acteurs, une liste de vétérinaires installés en clientèle privée a été obtenue au niveau de la sous-direction de la pharmacie et du secteur privé. Les acteurs interrogés sont répartis sur sept

régions du Cameroun : le Centre, le Littoral, l'Extrême-Nord, l'Ouest, le Nord-Ouest, l'Est et l'Adamaoua. Ainsi, 31 acteurs présents dans la zone d'étude ont accepté de participer à l'enquête (12 grossistes-importateurs-distributeurs de médicaments vétérinaires, 06 détaillants et 13 acteurs des services étatiques). Le questionnaire, rédigé en français et anglais a servi à collecter les données sur l'organisation et les problèmes liés à la distribution des médicaments vétérinaires. Ces données ont été saisies et analysées de façon descriptive en utilisant le logiciel Excel (Microsoft Corporation, Redmond, WA, USA).

## Résultats

*Réglementation sur la pharmacie vétérinaire au Cameroun*

Les échanges avec les autorités en charge de la pharmacie et du médicament vétérinaire ont permis de noter qu'il existe onze (11) textes réglementaires relatifs à la pharmacie vétérinaire au Cameroun. Ils concernent notamment :

Au niveau international :

1. Les Codes sanitaires pour les animaux terrestres et aquatiques de l'Organisation Mondiale de la Santé Animale (OIE). Ici, en prenant en compte les lignes directrices, la législation vétérinaire du pays devrait : (i) donner une définition exhaustive du produit vétérinaire en prévoyant les exclusions éventuelles ; (ii) réglementer l'importation, la fabrication, le commerce, la distribution et l'usage des produits vétérinaires. Le pays s'appuie sur les textes de l'OIE pour combler les lacunes. De plus, les agents antimicrobiens en médecine vétérinaire sont pris en compte dans les chapitres 6.6, 6.7, 6.8, 6.7, 6.8, 6.9, 6.10.
2. Les normes internationales du Codex Alimentarius donc le pays est partie prenante définissent les limites maximales de résidus (LMR) et les recommandations de gestion des risques (RGR) des résidus de médicaments vétérinaires dans les aliments.
3. L'Accord du 19 décembre 1984 relatif à l'harmonisation des législations et règlementations, zoo sanitaires dans l'Union Douanière et Economique de l'Afrique Centrale (UDEAC). Cet accord stipule à l'article 22 (1) que l'importation, l'exportation, la préparation, la détention, la vente ou la cession gratuite des produits et instruments à usage vétérinaire sont réservées aux personnes et aux établissements agréés dans les pays membres de l'union. (2) Le Secrétaire Général doit tenir à jour et communiquer aux Etats membres, la liste de ces personnes et de ces établissements. A l'article 23 que les Etats membres doivent mettre en œuvre les mesures nécessaires pour empêcher ou arrêter la circulation anarchique des produits et instruments à usage vétérinaire entre les Etats.
4. La loi n° 78/21 du 29 décembre 1978 portant création de l'Ordre National des Médecins Vétérinaires ; l'article 2 précise que l'Ordre veille au maintien des principes de moralité et de dévouement indispensables à l'exercice de la médecine vétérinaire, ainsi qu'à l'observation des règles éditées par le Code de Déontologie vétérinaire dont les dispositions seront fixées par décret.
5. L'arrêté n° 02/MINEL du 29 janvier 1980 portant définition des modalités techniques de commercialisation des produits à usage vétérinaire. Cette loi pose les bases du monopole du vétérinaire en matière de cession des médicaments vétérinaires. Ainsi elle précise que la cession se fait sous ordonnance délivrée par un professionnel. L'article 7 alinea « b » réserve la manipulation, l'utilisation ou la conservation des produits pouvant engendrer la chimiorésistance au praticien vétérinaire ; L'alinéa « d » du même article et l'article 8 soumet les antibiotiques et autres produits de la catégorie 2 à l'ordonnancement préalable d'un praticien compétent. L'article 11 réfère l'acquéreur des produits vétérinaire à l'ordonnance et l'article 12 revient sur le contrôle

des documents de mise en circulation et de commercialisation des médicaments vétérinaires par les praticiens attitrés.

6. Le Décret n°84/1053 du 18 août 1984 portant code de déontologie des vétérinaires ;
7. La loi n° 90/033 du 10 août 1990 relative à l'exercice et à l'organisation de la profession vétérinaire (médecine et chirurgie des animaux, pharmacie vétérinaire, conseil et étude en élevage, en industrie animale et en pêche). Cette loi confère l'exercice de la médecine, de la pharmacie aux docteurs vétérinaires et les obligations éthiques ordinales ; il ressort les cas d'exercices illégaux de la médecine et de pharmacie vétérinaire et les sanctions conséquentes. L'article 19 oblige le vétérinaire à se conformer à la législation en matière de détention et gestion des médicaments vétérinaires et l'article 23 revient sur les infractions à l'exercice de la profession vétérinaire notamment donné l'aide à toute personne non habileté à exercer, se livrer à l'importation, à la vente ou à la distribution des médicaments vétérinaires.
8. La loi n° 2000/018 du 19 décembre 2000 portant réglementation de la pharmacie vétérinaire au Cameroun (autorisation de mise sur le marché, importation, préparation industrielle, vente en gros, vente et distribution au détail). Cette loi définit qui est habileté à exercer la pharmacie vétérinaire et les conditions de fabrication, d'importation, de distribution en gros et en détail des médicaments vétérinaires, et des infractions et sanctions suites aux violations de la loi. Ainsi l'article 1 définit les médicaments vétérinaires et les aliments médicamenteux, l'article 3 prescrit comme préalable à la vente de médicaments vétérinaires l'obtention d'une autorisation de mise sur le marché. Cette loi définit en son article 1 aliéna 7, 12, 13 et 17, les acteurs pouvant intervenir dans la filière des médicaments vétérinaires au Cameroun. L'article 17 réserve la détention et la cession des médicaments vétérinaires aux docteurs vétérinaires (devoir de responsabilité) ou aux auxiliaires et groupements d'éleveurs sous la supervision d'un vétérinaire praticien, l'article 21 prescrit les sanctions à ceux qui délivrent les médicaments vétérinaires sans ordonnance ou qui dissimulent les médicaments vétérinaires aux contrôleurs.

La loi n° 2000/018 du 19 décembre 2000 portant réglementation de la pharmacie vétérinaire au Cameroun est la première loi spécifique à la pharmacie vétérinaire au Cameroun. Elle comporte des dispositions détaillées en matière de réglementation des activités de la filière des médicaments vétérinaires. Cette loi consacre 6 articles dans son titre II à l'Autorisation de Mise sur le Marché (AMM) des médicaments vétérinaires. L'article 3 de cette loi précise qu'aucun médicament vétérinaire ne peut être délivré au public s'il n'a reçu au préalable une AMM. La demande de cette AMM doit faire l'objet de la part du fabricant, de l'importateur ou du grossiste, du dépôt d'un dossier administratif et technique (article 4) qui est examiné par une commission créée à cet effet (article 5). L'AMM est accordée pour une durée de 5 ans renouvelable ; elle peut être suspendue ou retirée par décision du Ministre chargé des services vétérinaires, après avis de la commission prévue à l'article 5 (article 6). En ce qui concerne les acteurs devant intervenir dans la filière, la loi prévoit deux groupes d'acteurs : les grossistes-répartiteurs et les détaillants-distributeurs de médicaments vétérinaires. Selon l'article 1, alinéa 7, est grossiste-répartiteur de médicaments vétérinaires au Cameroun, tout vétérinaire ou toute société dirigée par un vétérinaire et propriétaire d'un établissement de vente en gros, se livrant à l'achat en vue de la vente en gros et en l'état des médicaments vétérinaires. Cette définition est complétée par l'article 12 qui précise que tout établissement de fabrication, de conditionnement et de vente en gros de médicaments vétérinaires doit être la propriété d'un docteur vétérinaire,

d'un pharmacien ou d'une société à la direction ou à la gestion de laquelle participent majoritairement ces derniers.

L'article 13 précise que les fonctions de vétérinaire ou de pharmaciens mentionnés à l'article 12 ci-dessus sont incompatibles avec la tenue d'une officine, l'exercice en clientèle et la vente au détail de médicaments vétérinaires. Cependant, l'article 17, alinéa 1 précise que seuls peuvent détenir des médicaments vétérinaires à titre gratuit ou onéreux en vue de leur cession aux utilisateurs et leur délivrance au détail :

i. les vétérinaires installés en clientèle privée dans le cadre de leur activité ;
ii. les groupements d'éleveurs agrées, en ce qui concerne les médicaments vétérinaires d'usage courant ;
iii. les auxiliaires agrées des vétérinaires agissant sous la supervision d'un vétérinaire praticien ;
iv. les agents des services vétérinaires de l'Etat, en ce qui concerne les médicaments nécessaires à la mise en œuvre des prophylaxies obligatoires dirigées par eux. Ils peuvent aussi distribuer les autres médicaments dans la mesure où aucun vétérinaire praticien ou groupement n'exerce dans la zone.

Dans l'alinéa 2 du même article, il est interdit à toute personne physique ou morale non agréée de vendre des médicaments vétérinaires aux utilisateurs. L'alinéa 3 quant à lui précise que les groupements d'éleveurs s'approvisionnent et distribuent les médicaments vétérinaires à leurs membres sous le contrôle d'un vétérinaire praticien.

9. Le décret N°2008/2909 du 08 décembre 2008 réglemente les conditions de fabrication, de conditionnement, d'importation, de vente et de distribution en gros et au détail des médicaments vétérinaires ; Ce décret précise la loi n° 2000/018 du 19 décembre 2000 portant réglementation de la pharmacie vétérinaire. Ainsi, l'article 13 revient sur la responsabilité personnelle et/ou solidaire du vétérinaire ou pharmacien sur le respect de la règlementation sur les médicaments vétérinaires ; ces responsabilités sont citées en article 16. L'article 18 indique les conditions de transport et de livraison garantissant la conservation, l'intégrité et la sécurité. L'article 23 précise les conditions d'ouverture d'une succursale qui obéissent aux mêmes procédures que l'agence principale. L'article 33 précise le contenu d'une notice de médicaments vétérinaires et les délais d'attente. L'article 44 interdit la vente au public des médicaments vétérinaires par des personnes physiques ou morales non agréées. L'article 45 subordonne l'acquisition des médicaments vétérinaires par l'éleveur à l'ordonnance obligatoire. L'article 46 réfère la liste des médicaments soumis à ordonnance à une décision de l'autorité vétérinaire (décision inexistante pour le moment). Les articles 49 et 50 confèrent le contrôle des médicaments vétérinaires aux responsables assermentés du MINEPIA. L'article 51 permet au MINEPIA d'interdire un produit suite à une simple suspicion de problème de qualité ou par principe de précaution, il permet aussi de faire des prélèvements pour les analyses non spécifiées aux laboratoires agréés. L'article 52 revient sur les modalités de destruction des médicaments vétérinaires dangereux.
10. L'arrêté n°178 CAB/PM du 05 décembre 2008 portant création, organisation et fonctionnement de la commission chargée d'examiner les dossiers de demande d'autorisation de mise sur le marché des médicaments vétérinaires participe de l'application des deux précédents textes de loi.
11. Le Décret n°2012/382 du 14 septembre 2012 portant organisation du Ministère de l'Elevage des Pêches, et des Industries Animales et fixant les missions, l'organisation et la structuration du MINEPIA au niveau central, régional et

départemental et précise les rôles et responsabilités des différentes structures et services rattachés spécifiant en son article 58 les responsabilités de la sous-direction de la pharmacie et du développement du secteur privé vétérinaires qui est chargée entre autre de l'élaboration et du suivi de la mise en œuvre des projets en matière de pharmacie et d'intrants vétérinaires et de l'élaboration et du control de l'application de la réglementation en matière de pharmacie et d'intrants vétérinaires, du suivi des activités des pharmacies, des laboratoires et de la commercialisation des intrants vétérinaires, de l' inspection pharmaceutique vétérinaire.

*Analyse de la réglementation sur la pharmacie vétérinaire*

Bien que la loi sur la pharmacie vétérinaire définisse un cadre juridique adéquat pour la production et la distribution du médicament vétérinaire, l'effectivité des textes reste restreinte. Malgré l'existence du décret N°2008/2909 du 08 décembre 2008 réglementant les conditions de fabrication, de conditionnement, d'importation, de vente et de distribution en gros et au détail des médicaments vétérinaires ; la plupart des textes ne sont pas toujours appliqués. Au regard de la loi, à ce jour :

i. il n'existe pas de centrale d'achat légale d'importation du médicament vétérinaire au Cameroun. Les vétérinaires qui exercent dans ce domaine le font sur la base des autorisations d'ouverture de cabinet professionnel. Cependant, certains bénéficiant d'autorisation d'ouverture, mais qui n'ont pas de cabinet professionnel sous-traitent leur agrément à des particuliers qui n'appartiennent pas à la profession vétérinaire ;
ii. il n'existe pas un système d'attribution de secteurs géographiques afin d'assurer une bonne couverture du territoire national par les grossistes répartiteurs et des détaillants, ce qui a pour conséquence l'apparition de défaillances au niveau de la distribution caractérisées notamment par l'absence de distinction entre grossiste-répartiteur et détaillant-distributeur;
iii. les produits distribués ne sont pas enregistrés et il n'existe pas un système d'assurance qualité à l'échelle du pays ;
iv. il n'existe pas une liste de médicaments mis à jour autorisés à l'importation : les importateurs choisissent leurs fournisseurs ;
v. l'inexistence d'une liste formelle des médicaments vétérinaires soumis à ordonnance conformément aux dispositions de l'article du décret n°2008/2908/PM du 05 décembre 2008 fixant les conditions de fabrication, de conditionnement, d'importation, de vente en gros et en détail des médicaments vétérinaires,
vi. il existe des sanctions en l'encontre des vendeurs de médicaments vétérinaires dans les marchés parallèles. Toutefois, elles ne sont pas mises en pratique de façon régulière malgré l'existence du décret n°2005/0528/PM du 15 février 2005 portant création, organisation et fonctionnement d'un comité ad hoc de coordination des opérations de lutte contre la fraude, la contrebande et la contrefaçon. Ce constat est renforcé par l'inexistence de décision conjointe entre le Ministère du Commerce et le Ministère de l'Elevage des pêches et des industries animales sur les médicaments vétérinaires contrefaits ou illicites à l'instar de celui existant entre le Ministère du Commerce et le Ministère de la santé publique sur les médicaments humains. L'article 2 dudit décret (n°2005/0528/PM du 15 février 2005) stipule que le comité a pour mission l'assainissement des opérations commerciales en vue de garantir une saine concurrence dans les activités économiques. A ce titre il est notamment chargé de relire le dispositif légal et réglementaire existant en vue d'en proposer les modifications éventuelles ; d'initier des enquêtes administratives ; de lutter contre l'importation, la détention ou la vente de produits provenant de la fraude, de la contrebande et la contrefaçon

; d'élaborer et de suivre l'exécution des programmes de prévention et de répression y relatif ; de proposer au gouvernement, toutes mesures susceptibles d'enrayer les circuits illicites de fabrication, de pénétration et d' écoulement des produits afin de contribuer à la garantie des recettes fiscales et douanières concernées ; de suivre l'application des sanctions prévues par les textes en vigueur en matière de fraude, de contrebande et de contrefaçon, des produits et de centraliser les informations et renseignements pratiques commerciales illicites.

vii. l'AMM n'est pas encore mis en pratique totalement. Les textes sur l'AMM existent à travers les articles 3 ; 4 ; 5 ; 6 ; 7 ; 8 ; 9 de la loi 2000/018. L'application des textes régissant l'AMM était prévue en 2011. Certaines firmes pharmaceutiques avaient déposé leurs dossiers en 2010, d'autres en 2011 et la commission a siégé pour la première fois en juillet 2012 et a validé 14 dossiers ;

viii. la sous-commission de la pharmacovigilance et de la vaccinovigilance prévu par le décret N°2008/2909 du 08 décembre 2008 réglementant les conditions de fabrication, de conditionnement, d'importation, de vente et de distribution en gros et au détail des médicaments vétérinaires n'est pas fonctionnelle ;

ix. il existe un vide juridique quant à l'organisation et le fonctionnement de la pharmacovigilance vétérinaire, processus d'évaluation continue du médicament post-autorisation de mise sur le marché.

x. la réglementation ne mentionne pas les conditions de contrôle et d'inspections de la chaîne de distribution ainsi qu'un guide de bonnes pratiques de distribution des médicaments vétérinaires pour assurer leurs qualités.

Ces insuffisances constatées dans les textes réglementaires expliqueraient en grande partie les dysfonctionnements observés dans le secteur de l'importation et de la distribution des médicaments et produits à usage vétérinaire au Cameroun.

*Distribution des médicaments vétérinaires au Cameroun*

Le circuit de distribution des médicaments vétérinaire au Cameroun est caractérisé par sa grande diversité en produits, origines et acteurs impliqués. Les investigations ont montré qu'il y a une coexistence entre deux circuits de distribution : circuit officiel ou autorisé et un circuit parallèle ou illicite illustré par la figure 1.

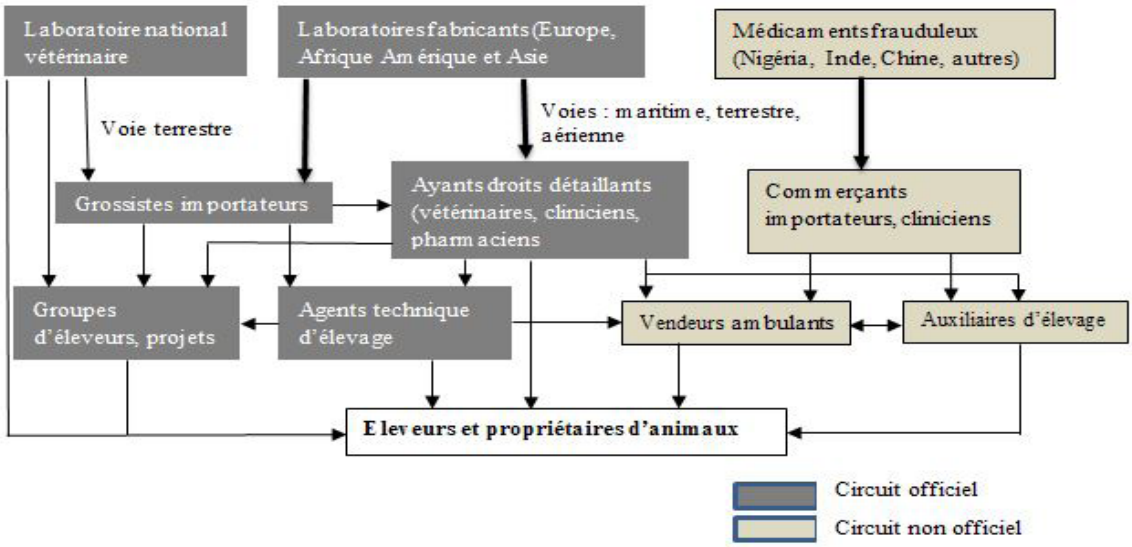



**Figure 1 :** Circuit de distribution du médicament vétérinaire au Cameroun

*Marché officiel*

Le marché officiel constitue le circuit de distribution des médicaments vétérinaires autorisé par l'Etat. Les principaux acteurs sont les importateurs grossistes-répartiteurs, les détaillants-distributeurs, les représentants de firme pharmaceutique, les groupements d'éleveurs. Ils ont l'obligation de suivre les différentes dispositions imposées par la réglementation en vigueur.

*Source d'approvisionnement*

Si la majeure partie des produits biologiques (vaccins) sont fabriqués localement par le Laboratoire national vétérinaire (LANAVET) de BOKLE-GAROUA, 97% des médicaments vétérinaires commercialisés proviennent des importations. Ces produits sont importés soit des pays Africains (Tableau 1) ou des pays de l'Union Européenne, Asiatiques et Américains (Tableau 2). La figure 2 qui illustre la répartition des importations indique que 47% des produits proviennent de l'Europe suivie de l'Asie (28%).

*Organisation de la distribution des médicaments vétérinaires*

Sur l'ensemble du territoire national 23 structures vétérinaires privées assurent l'importation et la distribution des médicaments vétérinaires avec une répartition très inégale. L'activité de distribution est plus concentrée dans 4 régions du pays (Tableau 3). Les délégués commerciaux des firmes pharmaceutiques et les groupements d'éleveurs disposant d'un vétérinaire exercent également l'activité d'importation et de distribution en gros des médicaments vétérinaires. Les conditions et procédures d'importation sont les suivantes :

i. disposer d'une autorisation d'installation en clientèle privée ;
ii. être inscrit (e) à l'Ordre National des Vétérinaires du Cameroun et agrément d'importation ;
iii. Posséder une patente.

Dans le schéma actuel de la distribution des médicaments vétérinaires dans le circuit formel, 100% des distributeurs importateurs dispensent en gros, demi-gros et en détail. La distribution capillaire au niveau des marchés à bétail et des campagnes se fait par des agents commerciaux de ces mêmes sociétés créant une concurrence déloyale aux détaillants agréés. De manière inverse 34% des détaillants importent directement leurs produits. Les entreprises importatrices sont principalement installées dans la ville portuaire de Douala, ce qui facilite la réception des produits commandés. La plupart d'entre elles disposent des agences dans les régions où les activités d'élevage sont importantes notamment dans l'Adamaoua, à l'Ouest, au Nord et à l'Extrême-Nord. Certains importateurs font la distribution au-delà des frontières nationales dans les pays de la Communauté Economique et Monétaire de l'Afrique Centrale (CEMAC) tel que le Tchad, le Nigeria, le Congo ou la République Centrafricaine. Le temps entre la commande des produits et leur livraison varie en fonction du moyen utilisé et de son origine. Ainsi, les médicaments transportés par voie maritime font 45-60 jours en provenance de l'Asie et 21 jours s'ils proviennent d'Europe. Par voie aérienne en revanche, le délai est plus court soit une semaine environ. Les difficultés liées à l'approvisionnement en médicaments sont dues au dédouanement des produits et matériels vétérinaires, la surtaxe des compléments alimentaires et vitamines puisque considérés par les autorités douanières et portuaires comme des aliments et des lenteurs administratives dans le traitement (93%) des dossiers avec pour conséquence des retards dans les commandes et les livraisons. La figure 3 qui illustre la répartition du marché des médicaments vétérinaires par quantités vendues en fonction des classes thérapeutiques indique que les antiparasitaires (54%), les antibiotiques (23%) et les vaccins (13%) sont les classes thérapeutiques les plus commercialisés. Parmi les antiparasitaires les trypanocides (36%) sont les plus dispensés.

La vente en détail est légalement assignée aux officines et cabinets vétérinaires privés. Les investigations ont permis de dénombrer 45 cabinets et cliniques vétérinaires privés assurant la vente au détail des médicaments

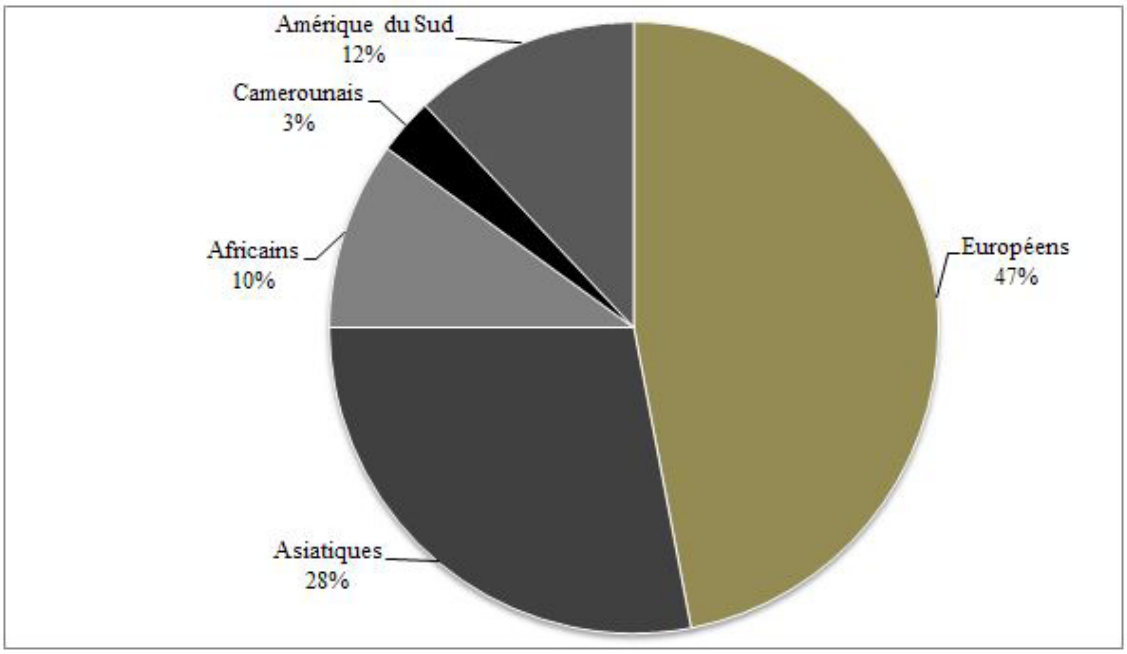
**Tableau I :** Laboratoires pharmaceutiques vétérinaires africains commercialisant les médicaments au Cameroun

| **Laboratoires** | **Pays d'origine** |
|---|---|
| Lanavet | Cameroun |
| Eagle Chemical | |
| Pfizer | |
| Global | Nigéria |
| Organics | |
| Jonferd | |
| Tuyil Pharma | |
| Calier | Maroc |
| MCI | |

**Tableau 2 :** Laboratoires pharmaceutiques vétérinaires européens, américains et asiatiques commercialisant les médicaments vétérinaires au Cameroun

| **Pays D'origine** | **Laboratoires** |
|---|---|
| France | Ceva, Amadeite, Merial, Laprovet, Vetoquinol, Lustiner, Qualian, Coophavet, Celtivet Acs International, Lcxpharma, LoBBs |
| Belgique | Kela, VMD, Mercodi, Laboratorios Calier Sa; |
| Espagne | Ovojero, Hippra Sa, Invesa. |
| Italie | Arion Fasoli S.R.L, Industria Italiana Intergratori Trei Spr. |
| Angleterre | Genevet Ltd. |
| Hollande | Alfasan International, Interchemie, Agrar |
| Chine | Shijiazhuang Sunway, Hebei Kexing Pharmaceutical, Shangai Fine Chemical, Shangai Agrochima International Trade, Shuanzing Tongren Pharmaceutical |
| Inde | Procyon, Vestergaad Frandsen, Appy Overseas Privated Limited, Pfizer Animal Health India Limited, Tagros, Cipla, Bennet Pharmaceuticals Limited , Sequent Scientific Limited |
| Corée du Sud | Eagle Vet Tech Co |
| Brésil | Ourofina |
| Canada | Topsurf Entreprise Pharmed |

vétérinaires. Ils sont principalement installés dans les villes de Douala, Yaoundé et Bafoussam (Tableau 3). Outre, les cabinets et cliniques vétérinaires, les groupements d'éleveurs et les agents des services vétérinaires de l'Etat, assurent aussi la dispensation au détail des médicaments vétérinaires. Les contraintes liées à l'approvisionnement en médicaments vétérinaires rencontrées par les détaillants sont dues à la rupture des stocks des grossistes dont ils sont dépendants, ou à cause des difficultés de transport pour acheminer le produit. Dans le cadre des projets d'appui au développement de l'élevage, les Organisations Non Gouvernementales (ONG) mettent des stocks de médicaments vétérinaires à la disposition des services vétérinaires qui les distribuent à moindre coût au niveau des cabinets et officines vétérinaires privés et approvisionnent les cliniques vétérinaires publiques de la région.




**Figue 2 :** Répartition des importations des médicaments vétérinaires commercialisés au Cameroun

**Tableau 3 :** Répartition des importateurs et détaillants de médicaments vétérinaires au Cameroun

| Régions | Importateurs | Détaillants |
|---|---|---|
| Ouest | Groupe Alivet Cameroun; Sophavet; CVO; Socavet | Vetogog Vetel; TGV; Cemavet; MVC²; Clinique vétérinaire la grace ; Veto prestation, Caphavet ; ANICARE santé animal, Modesa santé animal |
| Littoral | Huvavet, Medivet ; Modesa Santé Animal S.A, Cemavet, | Equavet; Medivet; MVC², Camvet; Cevetco; Vet Consult Promovet ; Vetsiko ; Niete Groupe ; Sanovet ; Vetcare ; groupe Alivet Cameroun ; caphavet ; Cemavet, TGV |
| Adamaoua | Camvet, Veto Sahel, Vetafric, Caphavet | Modesa santé animal ; Groupe Alivet Cameroun |
| Centre | Anicare Santé Animal, Veto Prestation, TGV ; Clinique Vétérinaire la Faune ; Cliniques Vétérinaire de Ngousso, Sep-Vet | Animal Paradise ; Vetafric, Caphavet ; Cemavet Mvc², Clinique Vétérinaire Schalom, Clinique Vétérinaire la Grace, Clinique Vétérinaire Bastos<br>CVO ; Clinique Vétérinaire des tropics, Sep-vet |
| Extrême-Nord | | Vetafric, Caphavet, |
| Est | | TGV, Cemavet, Caphavet, Groupe Alivet, Modesa santé animal |
| Nord | | Caphavet, Vetafric, Sepvet, afrique santé animale, |
| Nord-Ouest | | Grass roop veterinary service, Groupe Alivet Cameroun |

La délivrance des médicaments vétérinaires se fait au même titre que leur vente au détail. Dans les cabinets vétérinaires, elle se fait la plupart du temps sur prescription par un docteur vétérinaire ou son technicien ou encore à la suite de la présentation d'une ordonnance. Ici, la clientèle est généralement constituée de propriétaires d'animaux de compagnie. Par contre dans les pharmacies vétérinaires, au niveau des grossistes et des groupements d'éleveurs, l'ordonnance n'est pas toujours exigée. La clientèle concernée est en majorité constituée d'éleveurs. En cas de besoin, ces derniers s'adressent verbalement au dispensateur. Une fois sur le terrain, l'éleveur lui-même administre les médicaments aux animaux. Certains éleveurs se tournent vers le marché parallèle où les prix des médicaments sont relativement abordables bien que la qualité des médicaments vétérinaires qui y sont commercialisés n'ait pas l'objet d'investigation formelle.

*Marché parallèle ou illicite*

Comme la plupart des pays de l'Afrique subsaharienne, le marché parallèle des médicaments vétérinaires au Cameroun est essentiellement animé par les éleveurs, les provendiers, les petits commerçants et les auxiliaires d'élevage.

La masse de produits vétérinaires illicites retrouvés sur le marché camerounais provient principalement du Nigéria qui partage une frontière poreuse sur près de 4000 km et des pays asiatiques (Chine, Inde et Pakistan). Le marché illicite des médicaments vétérinaires au Cameroun est animé par plusieurs acteurs dont les non professionnels qui détiennent le circuit de vente illicite des produits.

## Discussion

Les données collectées lors de l'enquête abordent les aspects réglementaires et organisationnels du marché des médicaments vétérinaires ; elles concernent toutes les catégories d'acteurs de la filière. Il ressort que la pharmacie vétérinaire est réglementée par onze (11) textes juridiques (deux normes internationales, un accord sous régional, trois lois, trois décrets et deux arrêtés). Parmi ces textes, la loi n°2000/018 du 19 décembre 2000 portant réglementation de la pharmacie vétérinaire au Cameroun est la plus importante (Douffissa, 2013). Elle énonce les dispositions relatives à la demande d'AMM et d'enregistrement des médicaments vétérinaires, ainsi qu'à l'identification et les rôles de chacun des acteurs dans la filière. Cet arsenal juridique est proche de celui observé en République Centrafricaine et au Tchad (Essomba, 2009). Mais au regard des textes sur la pharmacie vétérinaire dans les pays de l'UEMOA (Sidibe, 2010) et le code sanitaire de l'OIE (2017), elle présente d'énorme insuffisances et limites. Ces défaillances pourraient s'expliquer par le respect de la législation et la réglementation en matière de pharmacie vétérinaire, l'insuffisance de ressources humaines compétentes et des moyens matériels et financiers y afférents. Ces insuffisances et limites dans l'application des textes peuvent être mieux cernées lorsqu'on considère que l'ensemble des dispositions législatives et réglementaires doit avoir un impact positif sur la qualité pharmaceutique, l'efficacité, l'innocuité, la sécurité des médicaments vétérinaires (Essomba, 2009), en plus les lois ne sont utiles ou n'ont de valeur que si elles sont adaptées à leurs contextes, appliquées et respectées par tous (Ndottiwa, 2008). En effet, ces textes sont perçus par le corps vétérinaire comme des sortes de projets, car leurs applications ne sont pas visibles sur le terrain. Cette affirmation se vérifie quand on constate que malgré la présence de l'article 3-(1) stipulant qu'aucun médicament vétérinaire ne peut être délivré au public s'il n'a reçu au préalable une autorisation de mise sur le marché délivrée par décision du ministre chargé des services vétérinaires, une dizaine de médicaments seulement vétérinaires sur plus d'une centaine ont une autorisation de mise sur le marché. Ceci montre que la quasi-totalité des médicaments retrouvés dans la présente étude n'ont pas d'AMM. Par ailleurs, cette défaillance sous couvert de tolérance administrative dans l'application des textes au Cameroun a également été observée dans

d'autre pays d'Afrique subsaharienne comme en Côte d'Ivoire (Oulai, 2004) et au Sénégal (Walbadet, 2007). Les dispositions légales fixant les conditions de contrôle sur la chaine de distribution ainsi que les répressions des fraudes étant pratiquement non appliquées. De plus, l'inexistence d'un système national de pharmacovigilance vétérinaire au Cameroun et un manque de textes règlementaires sur ce sujet conduit à des doutes sur la sécurité d'emploi des médicaments vétérinaires après AMM. La nécessité d'avoir à disposition des médicaments vétérinaires de qualité pour la protection de la santé animale, le développement de la production animale et la protection de la santé publique n'est plus à démonter. Il est donc important pour un pays d'avoir un système de pharmacovigilance fonctionnel afin de gérer tous les risques liés aux médicaments et d'en assurer l'efficacité. En droite ligne de ces évidences l'Etat camerounais gagnerait à mettre en place un système de pharmacovigilance vétérinaire reposant sur des bases juridiques nationales solides, soutenu par le leadership, et disposant de ressources adéquates pour accomplir ses missions.

Le marché officiel du médicament vétérinaire est caractérisé par une diversification accrue en termes produits vétérinaires et d'origines. 97% des médicaments vétérinaires circulant sur le territoire camerounais proviennent des importations de produits finis et conditionnés depuis pays d'origine. Les principaux fournisseurs sont les pays européens et asiatiques. Seul 3% des médicaments vétérinaires sont fabriqués au Cameroun. Ceci pourrait s'expliquer par le manque d'usines et de laboratoires de fabrication des médicaments vétérinaires dans les pays de l'Afrique sub-saharienne. Des études effectuées en Côte d'Ivoire ont montré des résultats similaires 97,7% provenaient des importations avec 87,5% des pays européens, 4,6% de l'Inde et 3,6% de l'Afrique du sud (Assoumy, 2009).

Le nombre important de sources d'approvisionnement et de marques de médicaments vétérinaires disponibles sur le marché serait lié à deux facteurs. La logique économique oblige les acteurs (importateurs-grossistes) à privilégier les médicaments les moins chers. Cette situation expliquerait l'importance des médicaments vétérinaires provenant de l'Asie sur les marchés africains en général et camerounais en particulier. Dans un contexte où le dispositif de contrôle ou d'assurance qualité est insuffisant voire inexistant, la qualité des dits médicaments vétérinaires est questionnable étant donné la position de l'Asie (classée numéro 1 mondial) en matière contrefaçon des médicaments vétérinaires (Messomo, 2006). En effet, si l'identification des sources d'approvisionnement est un impératif à la garantie de la qualité des médicaments vétérinaires commercialisés dans un pays, alors l'unité de production est le premier maillon de la filière qui doit garantir la qualité du produit (Têko-agbo *et al*., 2009).

Sur l'ensemble du territoire national 23 structures vétérinaires privées assurent l'importation et la distribution des médicaments vétérinaires avec une répartition très inégale. L'activité de distribution est plus concentrée dans 4 sur 10 régions du pays. La dispensation en détail est légalement assignée aux officines et cabinets vétérinaires privés. Ils sont principalement installés dans les villes de Douala, Yaoundé et Bafoussam et Ngaoundéré. Cette répartition se justifie par la facilité d'acquisition des produits à partir du port ou des aéroports pour ce qui est des villes de Douala et Yaoundé. La région de l'Ouest et de l'Adamaoua étant des grands bassins de productions avicole et bovins respectivement, l'utilisation des médicaments dans le traitement du bétail devient un impératif d'où la proximité de ces structures.

Des dysfonctionnements se sont observés dans le circuit de distribution des médicaments vétérinaires au Cameroun. Ce manque de discipline a été observé dans d'autres pays de la sous-région Afrique Centrale et de l'Ouest (Walbadet, 2007). Cette situation constitue un obstacle qu'il est important de régler pour spécifier le champ d'action de chaque acteur de la distribution du médicament. S'il est vrai que la réglementation prévoit que le grossiste devrait uniquement

vendre en gros et le cabinet en détail, cette étude montre l'absence d'une segmentation effective des activités de vente en gros et de vente au détail. C'est ainsi que 34% de détaillants ont déclaré importer des médicaments et tous les grossistes ont déclaré vendre au détail. Ceci pourrait s'expliquer d'une part par la non-application effective ou de la transgression des textes réglementaires qui régissent le secteur de la pharmacie vétérinaire.

La réglementation stipule que les importateurs ne devraient à limiter à la distribution de gros et ne pas détailler. Toutefois si les proportions d'importateurs et de détaillants sont égales ou proches, les détaillants subissent une concurrence illégale et déloyale de la part des grossistes et sont un peu mis à l'écart voire marginalisés par les importateurs qui détaillent aussi et pratique des prix plus favorables aux éleveurs que ceux des détaillants. Parallèlement, si les importateurs se limitent strictement aux importations telles que régies par les textes, ils ne pourront pas facilement écouler leurs produits car le ratio importateur: détaillant est proche de 1 et que le maillage ou la médicalisation du territoire national par les détaillants n'est pas complète. Ceci expliquerait le comportement la non distinction entre importateurs répartiteurs et détaillants dans certaines localité du pays. Ce désordre peut entraîner une saturation très rapide du marché obligeant certains grossistes en quête d'une clientèle, à distribuer leurs produits même dans le circuit parallèle à l'instar de la situation décrite au Sénégal par Thiam (2002). Le non-respect de la réglementation aura donc pour conséquence directe la marginalisation des moins armés financièrement pour mener cette « guerre ». Certains acteurs du secteur privé inaptes à supporter la situation accablante de la distribution du médicament sont obligés de se reconvertir dans d'autres domaines. De plus, le rôle l'Etat se limite à la délivrance d'une autorisation d'importation des médicaments vétérinaires. La régulation est insuffisante caractérisée par l'absence de contrôle stricte au niveau des points d'entrée et au niveau de la distribution des médicaments sur le territoire, d'enregistrement des médicaments et l'inexistence d'une liste de laboratoires autorisés à fournir les médicaments vétérinaires. Des observations similaires ont été décrites au Rwanda (Ndayisenga, 2009), à Madagascar, (Ratalata, 2008) et au Sénégal (Walbadet, 2007).

La répartition du marché des médicaments vétérinaires par quantités vendues en fonction des classes thérapeutiques a montré que les antiparasitaires, les antibiotiques, les vaccins et les vitamines sont les plus commercialisés. Parmi les antiparasitaires les trypanocides occupent 1/3 des ventes. Ceci pourrait s'expliquer par l'importance du cheptel bovin dans la zone de haute savane guinéenne et soudano-sahélien du pays. Estimé à 70% du cheptel bovin national d'une part (Gambo, 2017) et d'autre part du fait que la trypanosomiase animale est endémique au Cameroun (Mpouam *et al*., 2010) et l'utilisation des trypanocides devient incontournable pour la chimioprévention et la chimiothérapie (Mamoudou *et al*., 2009). Ces résultats corroborent ceux d'Assoumy (2009) en Côte d'Ivoire. Les médicaments les plus vendus sont les antiparasitaires (35,85%) avec 14,34 % de trypanocides. Des cas similaires ont été observés au Bénin-Togo, Mali, Mauritanie, et au Tchad.

La distribution du médicament vétérinaire dans le circuit illicite est assurée par des agents non professionnels assez bien organisés. Les produits transitent par les ports et aéroports ou par voie terrestre pour inonder les marchés. Les acteurs sont constitués principalement d'investisseurs, de commerçants, de revendeurs ambulants, de provendiers, de techniciens d'élevage et d'éleveurs. Ce circuit se développerait à la faveur de plusieurs facteurs parmi lesquels le l'insuffisance d'application des textes régissant l'exercice de la pharmacie vétérinaire, le manque de répression de la part de l'Etat. En effet, comment expliquer que les acteurs du marché parallèle de médicaments vétérinaires paient-ils des taxes officielles aux mairies pour exercer une activité illégale ? Les conséquences de ce fléau sont d'ordres sanitaire, économique et social. Les préjudices sanitaire et économique indirecte découlent de la mauvaise qualité et du

mauvais usage des médicaments vétérinaires que mobilise ce circuit. La persistance des maladies animales s'accompagne généralement d'une baisse de productivité qui freine ainsi le développement de l'élevage dans le pays. Quant au préjudice économique direct, le marché parallèle des médicaments vétérinaires cause un important manque à gagner aux acteurs du marché officiel (Têko-agbo *et al*., 2009).

## Conclusion

Les médicaments vétérinaires jouent un rôle important dans la protection animale. Au regard des résultats de cette étude, le secteur de la pharmacie vétérinaire au Cameroun est réglementé bien que ces textes présentent de nombreuses insuffisances. La structuration du marché tel que prévu par la loi n'est pas respecté. De même la répression contre le marché illicite des médicaments vétérinaires n'est pas toujours efficiente. La révision et l'harmonisation des réglementations nationales qui sont à la base du respect des bonnes pratiques apporteraient leur concours dans les domaines de l'Autorisation de Mise sur le Marché, du système d'assurance qualité, de l'approvisionnement, du développement des ressources humaines, de la pharmacovigilance, des bonnes pratiques de fabrication, de distribution et d'utilisation des médicaments vétérinaires au Cameroun et dans la sous-région Afrique Centrale.

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# ANALYSIS OF CURRENT STATUS OF POULTRY VALUE CHAIN IN ETHIOPIA: IMPLICATION FOR INFORMATION GENERATION AND EXCHANGE: A REVIEW

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## Abstract

The objective of this paper was to review the current status of the poultry value chain in Ethiopia. According to the recent findings, there are about 59.5 million chickens in Ethiopia. Out of these, 54.1 million (90.85%) are indigenous, 2.6 million (4.39%) are exotic and 2.8 million (4.76%) are hybrids. Scholars have previously explained that poultry production in Ethiopia can be classified in various ways such as small, medium and large with a poorly developed and traditional poultry value chain. Reports have shown that the poultry value chain distribution approach has been better practiced than the input-output approach mainly under smallholder production system. However, in the large scale production system, both the input-output and the poultry value chain distribution approach have been practiced following the dynamics of poultry technologies and involvement of both national and international poultry research institutions (EIAR and ILRI), investments and interventions. Researchers indicated that the flow of information along the poultry value chain (Poultry Value chain Mapping) has not yet been thoroughly investigated. Reports have shown that the poultry value chain actors are variable along the different areas of Ethiopia. Some of the poultry value chain actors studied were chicken multipliers and distributors as input suppliers, poultry producers(for production purposes), poultry collectors and transporters, poultry wholesalers and retailers, restaurants and cafeterias and consumers (end users) as in the case of North Ethiopia (Adwa areas). Moreover; some of the poultry value chain actors in the southern part of the country were poultry producers, urban assemblers and village assemblers, wholesalers and retailers, brokers, processors, supermarkets, hotels, restaurants and consumers. Scholars have shown that the poultry value chain enabling environment is not yet conducive enough. The tax systems (import of essential inputs) have been shown to be quite challenging. The shortages of Foreign exchange, inadequate supply of feeds and an insufficient knowledge base have additionally been cited as major hindrances of the poultry value chain. Research has shown that there is a chronic shortage of day old chicks and fragmentation of distribution channels in the country. Some of the opportunities in the poultry value chain have been identified as: existence of governmental (MoAL) and non-governmental institutions (ILRI and Commercial companies), recent higher prioritization by government and high population size (over100 million people). The poultry value chain is very fragmented and poor. The poultry production taxation system is also inadequate requiring research and policy interventions. Clear policies and strategies for the poultry value chain in Ethiopia should be formulated through the integrated efforts of the public and private sectors. There is also a need for capacity building (more practical oriented training) along the entire poultry value chain throughout the country.

**Key words:** Analysis, Poultry, Value chain, Status, Ethiopia

## Introduction

Poultry is the largest livestock group in the world estimated to be about 23.39 billion consisting mainly of chickens, ducks and turkeys (FAO., 2011; FAO., 2007) and has remained to be important in the improvement of food security and livelihood (Zemelak *et al*., 2016) and contributing about 28-30% of all animal protein consumed in the world (FAO., 2011; ILRI., 2014).

Reports also disclosed that the total chicken population in Ethiopia has increased (CSA, 2011; ILRI, 2014) and is estimated to reach above 59.5 millions (CSA, 2014; FAO, 2011). Moreover; it has also been reported that village chicken production accounts for more than 90% of the total chicken production where exotic and hybrid chicken constitute above 10% of the chicken production in the country (CSA, 2014; ILRI, 2014).

Studies have shown that the price of agricultural products particularly poultry products have been rising both in domestic as well as international markets due to rising incomes in newly emerging developing nations and high population growth (Aklilu *et al*, 2007). Poultry products have very high income elasticity and demand increases rapidly with rising income as countries shift from lower to middle income economies (Auke *et al*, 2015). Increases in poultry consumption have been particularly dramatic and widespread, while changes in beef, pork, and dairy demand vary with cultural differences between countries (Ekin *et al*, 2008). Future meat demand is expected to grow at roughly equivalent rates in different developing countries (Vernooij *et al*, 2012).

Scholars have explained that Agricultural product value chains in general and poultry in particular have been disclosed to be the main driving force of economic development and have a guiding and stimulating impact on production and distribution of poultry and poultry product production (FAO, 2014). The poultry marketing system has taken on increasing importance as a traditional agrarian society has been transformed into a modern industrial society (CSA, 2014). The increasing proportion of the population living in urban centers and the rising levels of income requires more highly organized channels for processing and distributing agricultural products in general and poultry in particular (ILRI, 2014).

Various research efforts have been undertaken to improve poultry production and productivity in Ethiopia. A review of past research works has indicated that the research largely concentrated on the biological aspects of poultry production such as supplementary feeding and breeding (Fisseha *et al*, 2010). Increased production, however, needs to be accompanied by efficient marketing systems and one means of investigating the efficiency of the chicken marketing system has been through studying and identifying factors that determine the market chain of chicken (Shepherd, 2007).

Research has shown that the Ethiopian poultry value chain is not well developed and has been explained to be traditional (Dawit *et al*, 2008). Marketing of poultry and poultry products at open markets has been reported to be common throughout the country and both live birds and eggs have been sold on road sides (Gebregiziabher, 2010). The poultry value chain has been reported to be often very short mainly through a direct interaction of producers and final consumers in live-bird markets which has been described as a simple poultry value chain (Aklilu *et al*, 2016). Governmental and nongovernmental organizations have taken initiatives to improve livestock value chains in general and the poultry and poultry products value chains in particular (ILRI, 2014). Livestock and Irrigation Value Chains for Ethiopian Smallholders (LIVES) project has been initiated with the objective to transform smallholders into more commercial farmers through value chain based interventions in high value livestock commodity development including poultry and poultry products (ILRI, 2014).

Researchers have shown that poultry value chain activities have shifted products from its producer to its end user and include production, marketing and distribution (CSA, 2014). Poultry value chain could be defined as the range of activities required to bring

poultry meat or eggs to consumers via the different phases of production, marketing and distribution with added values (Awol, 2010). It can also be described as market focused collaboration among different stakeholders who produce and market value added products. Value chain analysis helps to understand the production system, marketing channels and their relationships, the participation of different actors, and the critical constraints that limit productivity and the competitiveness of the producers of various scopes (FAO, 2014). Others have also informed that the poultry value chain involved a number of actors such as farmers, assemblers, wholesalers, retailers, processors, urban consumers and cooperatives (CSA, 2014). Households sold majority of their birds and eggs directly to urban consumers (FAO, 2014). Assemblers, retailers and wholesalers purchase the majority of birds and eggs sold (Ekin *et al*, 2008). Processors and cooperatives made rather a limited contribution in the supply chain (Aklilu, 2007).

## Review

*Definition of Poultry Value Chain and Poultry Value Chain Related Terms*

References have shown that different value chain dictionaries have been to be elaborated to make ease of readers with various scopes at all levels and scholar environments (USAID, 2006).

*Definition of Poultry Value Chain*

References have explained that the poultry value chain could be defined as the full range of activities required to bring a product (meat, egg) to final consumers passing through different phases of production, processing and delivery (Aklilu et al, 2016). It can also be defined as a market focused collaboration among different stakeholders who produce and market value added products (USAID, 2006). Others also defined as the sequence of productiveprocessfrom the provisionofspecific inputs for a particular product for a primary production, transformation, and marketing and up to the final consumption (FAO, 2012). It can be defined as an institutional arrangement linking and coordinating producers, processors, traders and distributors of a product such as poultry and poultry products (ILRI, 2014).

*Definition of Value Addition in Poultry*

References informed that value addition in poultry could be defined as a process of changing or transforming a poultry product from its original state to more valuable state of consumers (Aklilu *et al*, 2016).

*Definition of Poultry Value Chain Selection*

References have indicated that poultry value chain selection has been defined as a process of deciding on which poultry value chain poultry enterprise should develop in order to get the maximum benefit from its investment and innovations starting at the early planning stage of the chicken and chicken product enterprise of the value chain process (Aklilu *et al*, 2016).

*Definition of Poultry Value Chain Mapping*

Reference have shown that poultry value chain mapping has been defined as a graphical representation of a process by which poultry product of value could be created or modified and showed what should be done to create value and who should do it as taking in to account the mitigations and interventions in the whole value chain process explained as graphical scheme (Aklilu *et al*, 2016).

*Definition of Poultry Value Chain Analysis*

Poultry value chain analysis is a tool for working out how you can create the greatest possible value for your consumers and the best way to maximize profit (FAO, 2014).

Overview on Poultry Production Systems in Ethiopia Different authors classified poultry production system in Ethiopia as small, medium and large based on the chicken types and their scale of production system dynamics. Reports also showed that small scale chicken production system account for more than 95% of poultry production in Ethiopia (Mekonnen*et al*., 2010).

Besides; small scale production system could be classified into three as traditional free range poultry production system(having less than 10 chickens), improved free range poultry production system (having less than 50 birds) and small scale confined poultry production systems (some hybrid inclusive) having range from 50-1000 bird( FAO,2012).Different scholars also classified poultry production system in Ethiopia as village, peri-urban and urban based on the chicken types, purpose of production, level of technologies used and their production environment and the village chicken ecotypes have been vast and important specially for women in developing courtiers like Ethiopia (CSA,2014).

Reports also showed that poultry production in Ethiopia could be classified as extensive, semi-intensive and intensive based on their level of intensity of production, confinement and production objectives set. Moreover; various researchers informed that chicken ecotypes could be classified based on their Agro-ecological conditions (Shishay *et al*, 2014).According to the GTP-II of Ethiopia master plan poultry production system could also be classified as scavenging, semi-scavenging and commercially confined depending on the level of feed and feeding technologies, the chicken types and purpose of production intended in the country (ILRI, 2014)

*Poultry Value Chain and Value Chain Actors in Ethiopia*

References have shown that large-scale farms provide information and advice to small-scale and backyard farmers (USAID, 2006). Large-scale farms significantly contribute to knowledge spread through their use of imported technologies which may not have been introduced earlier and via the importation of DOCs, which may not have been previously evaluated important skills and values in the value chain business interactions (FAO, 2012). Large-scale farms were also identified as one of the most influential actors in terms of movement modern inputs through many direct and indirect involved value chain actors along the value chain in Ethiopia (ILRI, 2014).

Reports have shown that The network mapping exercise could be impose to influential actors/institutions in the assimilation of modern poultry technologies for small-scale farms and the influential actors have been mentioned as assemblers, retailers, transport facilities; followed by traders and feed processors through the exchange of feed and wholesalers, hotels and restaurants, and processors through the proper disposal of wastes from the whole poultry vale chain processes in the country (Aklilu *et al*,2016).

*Poultry Producers along the Value Chain in Ethiopia*

References have disclosed that local poultry producers have been smallholders who mainly produce indigenous and dual purpose chickens (Awol, 2010). There are also commercial layer and broiler producer in Ethiopia and poultry size of poultry producers varies depending on agro ecological setting and wealth of the producer (Aklilu, 2007). Larger herd sizes are usually observed among local poultry producers, but herds are very small in commercial layer and broiler producers. Local poultry producers tend to sell for cash and their chickens are important sources of egg and meat for the household (USAID, 2006). It is important to note the local poultry value chain behavior is considerably variable among the chicken producers in Ethiopia (Mekonnen, 2007).

Scholars have shown that local poultry producer intends to sell his/her chickens not based on demand, but rather most producers (especially those who have very small poultry) sell their chicken when cash is needed to meet obligations (EMMA, 2013). Thus supply of local poultry to the various value chains is governed by factors apart from market price incentives (Shepherd, 2007). Poultry producers sell their chickens mainly at the beginning of the school year to pay school expenses for children and religious festivals such as Easter, Christmas and Ramadan (FAO, 2014). Local poultry producers usually sell their chickens in nearby for the primary value chain actors. The poultry feed producers for local chickens are non conventional feeds while the commercials

get from commercial feed processing plants found primarily in urban and peri-urban areas (FAO,2012).

*The Poultry and Poultry Product Collectors along the Value Chain in Ethiopia*

References have explained that poultry and poultry product collectors could be producers or small traders who trade chicken as a part-time or full business (FAO, 2012).The sources of capital for collectors vary depending on relationships they have with their buyers and the level of trust they have developed with traders (ILRI, 2014).Those poultry and/or egg collectors who have developed trust with traders usually get advance payment from these traders so that they will collect chickens and/or eggs satisfying the trader's quality requirements (USAID, 2006).

*The Large Scale Poultry and Poultry Product traders across the Value Chain in Ethiopia*

Scholars have shown that poultry and poultry product traders who supply thousands of chickens a week to export urban consumers and larger service providers (national and international hotels) in the country (FAO,2014). Large-scale poultry traders have a network of small traders and collectors that will collect chickens and/or eggs from different corners of the country. Some chicken and chicken product providers lounge a premium prices to traders that can supply thousands of chickens and chicken products (). Suppliers have found to establish their collection networks and try to supply as many chickens and/or eggs as they can base on the profitability of the service providers (ILRI, 2014).

These Poultry Value chain actors are those involved in input supply, producing, processing, trading and consuming the poultry and eggs (Zemelak *et al*, 2016). It includes the direct actors such as input suppliers, producers, traders and consumers and indirect involved institutions (FAO, 2014). Each actor plays specific roles at different points of the value chain. Households produce poultry and eggs, they exchange breeding stock with neighbors, or buy from traders, market and hatchery. Eggs are sold to primary egg collectors, neighbor, and local market to local consumers. Secondary traders transport eggs from rural areas to urban markets where they sell to urban consumers through supermarkets, shops and restaurants. In a wider sense, certain government agencies at the macro level can also be seen as value chain actors if they perform crucial functions in the business environment of the poultry value chain intended (USAID, 2006).

*Service Providers and Individual Consumers across the Poultry Value Chain in Ethiopia*

References have mentioned that service providers (such as Hotels) are the major outlets for poultry and poultry products in Ethiopia (FAO, 2012). They buy poultry and products and process them into different dishes. Most hotels have permanent poultry and poultry product suppliers (usually small-scale traders). Some hotels also buy from producers or collect in poultry and poultry product markets. Individual consumers usually buy poultry or eggs during religious festivals. The type of chicken demanded by individual consumers varies with the wealth of the consumer and poultry and poultry products are more affordable than other animals for financially poor households (EMMA, 2015).

*Poultry Value Chain Approach and Mapping in Ethiopia*

References have shown that there have been various poultry value chain approaches and the mapping of the value chain could also be different in different both developed and developing countries (Dawit *et al*, 2008).

*Value Distribution Approach of Poultry in Ethiopia*

References shown that this approach usually shares of retail value added or final retailer price are used as proxies for the division of value added or economic surplus. However, this approach has overlooked differences in production costs as well as being unpredictable (Some retailers add a higher margin) both in developed and developing countries (Ekin *et al*, 2008).

*Input-Output Poultry Value Chain Approach in Ethiopia*

Undertaking firm level input-output approach is another value chain approach. Moreover;this approach assumes firms produce in a vacuum and that a change to the tune of a given value will result in an increase of value added product of another corresponding value in the value chain (FAO,2012).This approach may be relevant if the firms are in isolation and independent of global market (Auke *et al*,2015).

*Some Poultry Value Chain Mappings in Ethiopia*

References have shown that (Mapping the flow of information along the poultry value chain) has been crucial for the identification of the actors to whom poultry participants should be communicated. Each actor in the poultry sector, whether private and public, or formal or informal, has particular roles in the value chain communication process. Network mapping exercises help to identify the different actors involved in the poultry value chain, and to understand their roles, linkages, and influence the poultry value chain information (Aklilu *et al*, 2016).

References have shown that value chain mapping has been explained as the graphical representation of input supply, production functions, processing, trading and consumption within value chain actors (USAID, 2006). So, poultry value chain mapping was done to identify the core process, value chain actors and their activities at each stage. It was also performed to understand the characteristics of the chain actors and the relationships among them in the chain such as the flow of goods through the chain, employment features, the destination and volumes of the domestic sales. The value chain map shows the flow of poultry chain, activities carried out at each stage of the value chain (Scenario 1).

**Scenario 1. Poultry value chain mapping in some areas of Ethiopia**

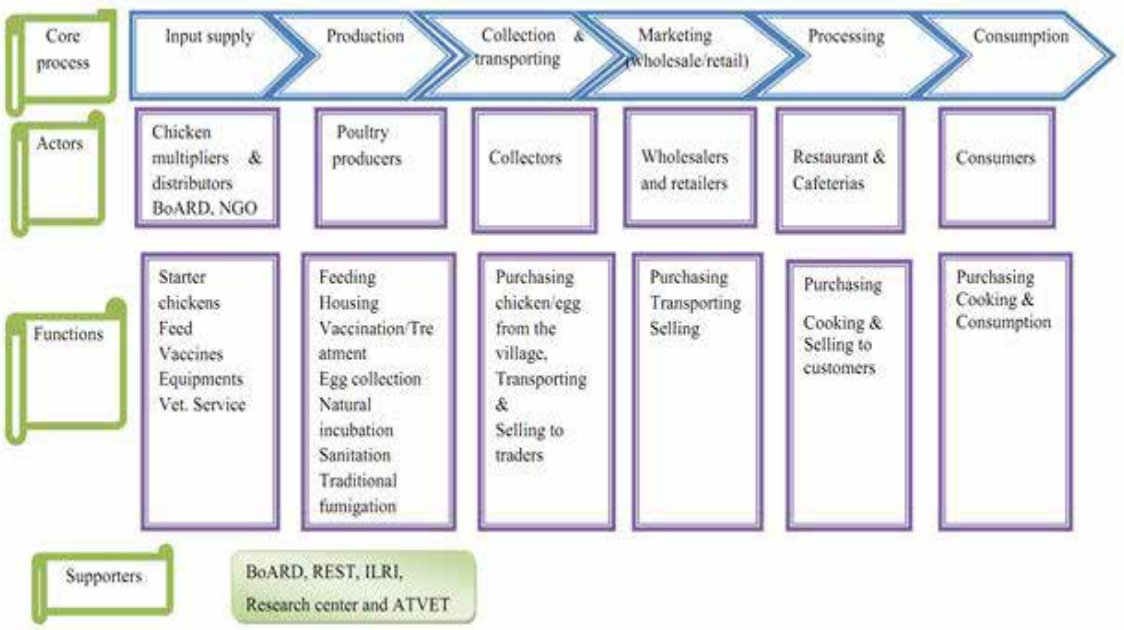



**Figure 1:** Poultry value chain map study of Adwa of Tigray region, Ethiopia

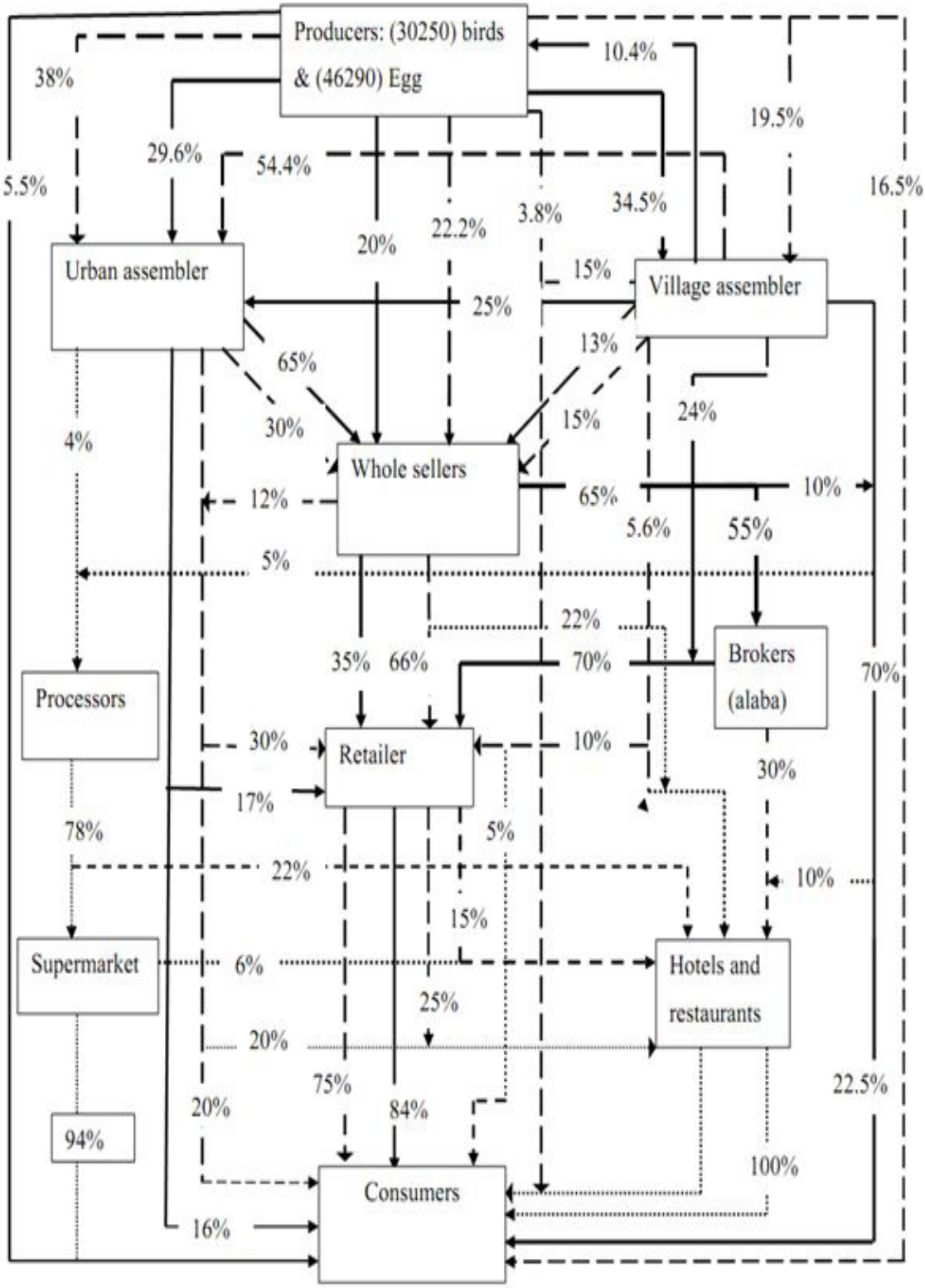



**Figure 2:** Poultry value chain mapping in Ethiopia

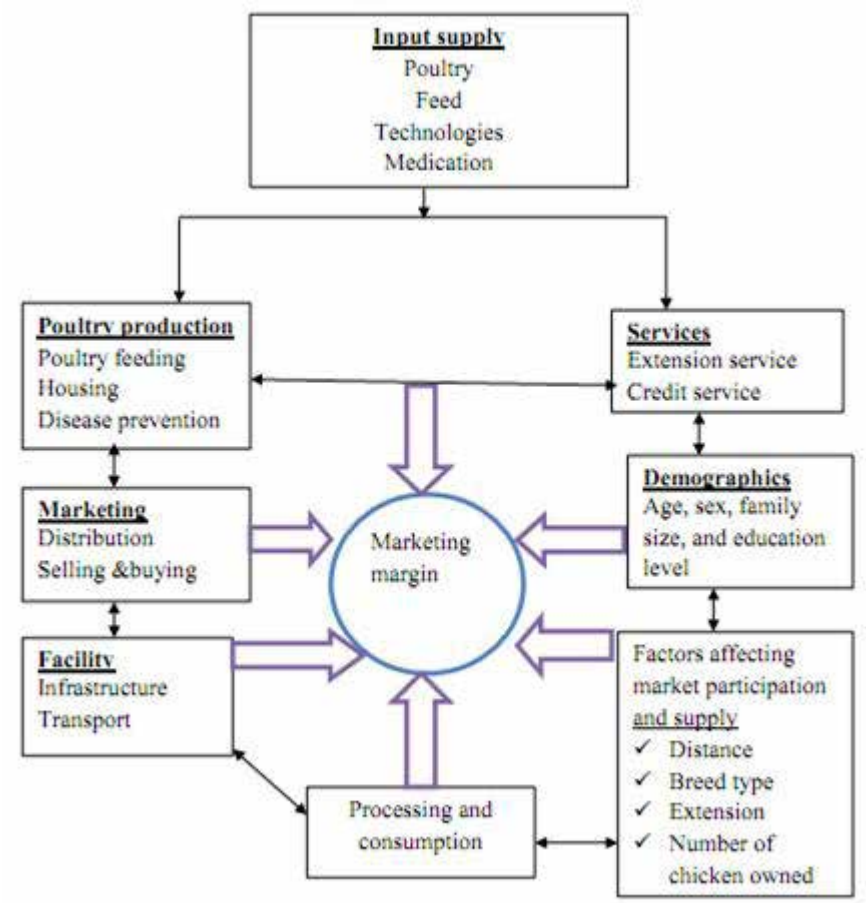



**Figure 3:** Poultry value chain frame work in Ethiopia

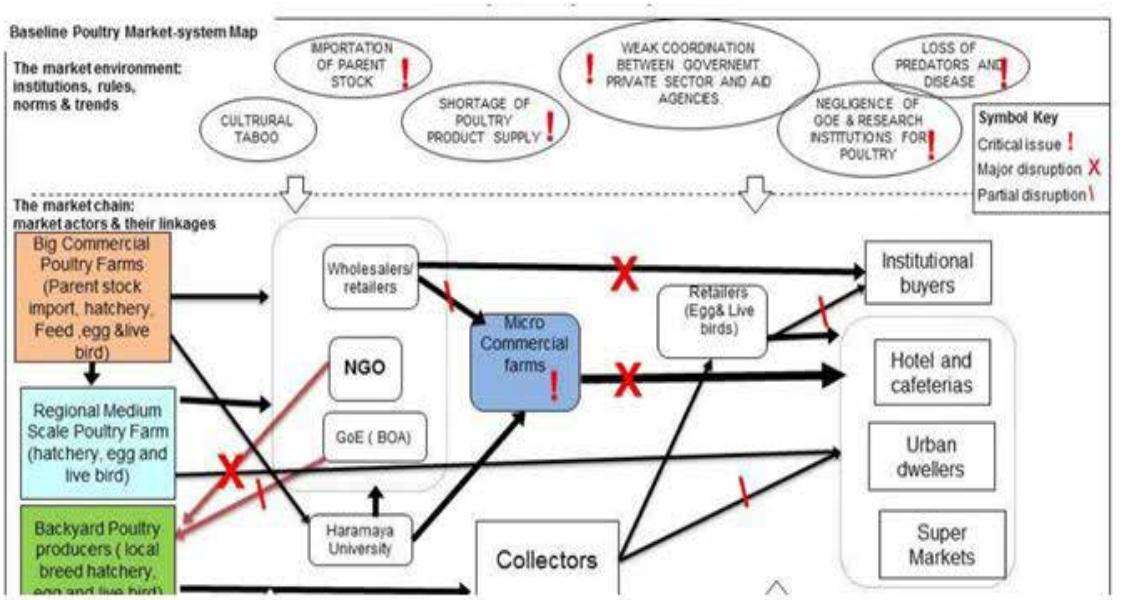



**Figure 4:** Poultry value chain actors (Direct VS indirect) in Ethiopia

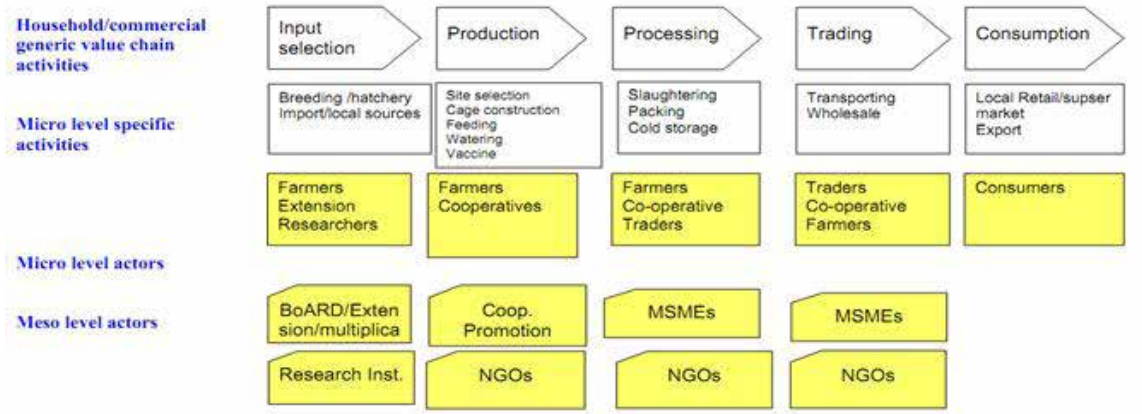



**Figure 5:** Poultry Vale chain actors in Ethiopia

*Poultry Value Chain Analysis in Ethiopia*

References have shown that Value chain studies, including production system and market chain studies, are essential to value chain analysis, which when coupled with poultry product analysis has been a powerful tool to identify key constraints and opportunities for value chain control based on poultry management in the production and marketing system. Several production system and market chain studies have been conducted to support different poultry strategies and interventions in both developed and developing countries. This practical aid is intended as an adjunct to the FAO value chain approach. Further practical advice is provided for more effective use of value chain studies in poultry as part of decision support (Shishay *et al*, 2010).

## Steps in Poultry Value Chain Analysis

*Step 1. Identify the firm's primary and support activities*

All the activities (from receiving and storing materials to marketing, selling and after sales support) that are undertaken to produce goods or services have to be clearly identified and separated from each other. This requires an adequate knowledge of company's operations because value chain activities are not organized in the same way as the company itself. The managers who identify value chain activities have to look into how work is done to deliver customer value (FAO, 2012).

*Step 2. Establish the relative importance of each activity in the total cost of the product*

References have shown that the total costs of producing a product or service must be broken down and assigned to each activity. Activity based costing is used to calculate costs for each process. Activities that are the major sources of cost or done inefficiently (when benchmarked against competitors) must be addressed first (FAO, 2012).

*Step 3. Identify cost drivers for each activity.*

References haveshown that, only by understanding what factors drive the costs, managers can focus on improving cost driving factors. Costs for labor-intensive activities will be driven by work hours, work speed, wage rate, etc. Different activities will have different cost drivers (FAO, 2012).

*Step 4. Identify links between activities*

References have shown that Reduction of costs in one activity may lead to further cost reductions in subsequent activities. For example, fewer components in the product design may lead to less faulty parts and lower service costs. Therefore identifying the links between activities will lead to better understanding how cost improvements would affect the whole value chain. Sometimes, cost reductions in one activity lead to higher costs for other activities (FAO, 2012).

*Step 5. Identify opportunities for reducing costs*

When the company knows its inefficient activities and cost drivers, it can plan on how to improve them. Too high wage rates can be dealt with by increasing production speed, outsourcing jobs to low wage countries or installing more automated processes (FAO, 2012).

## Opportunities for improving Poultry Value Chain in Ethiopia

The survival and profitability of a small scale enterprise like a small poultry business depends on the qualities of the person who starts the business. Entrepreneurs have special traits that are measurable through some psychological tests and social indices. People possessing these traits and social indices at a certain level are expected to be more successful than those without them (Awol, 2010).

Scholars informed that Farmers can grow poultry feed components like soya, maize, millet, sorghum, sunflower, rice, and cotton and sell to feed manufacturing companies or to farmers mixing their own feed at home. Farmers can brood day old chicks into month old chicks and sell to farmers who fear the process and risks involved in brooding and make huge margins. Farmers can raise their chicken to maturity and sell meat or eggs through contract selling to organized markets. Farmers can collect the highly effective chicken manure and sell to other farmers planting other crops. Shrewd business people can seek knowledge on feed formulation, mix the various categories of feed for layers, growers and chick marsh and sell to other poultry farmers (Mekonnen, 2007).

References have indicated that business people can act as agro-vet dealers and stockiest for poultry related inputs like vaccines, feed feeders and drinkers among others to serve farmers in a given region. Accounts clerks can help local farmers in record keeping and book keeping to ensure they keep track of their expenses and incomes. Local extension service providers can offer training and extension services to farmers. A slaughter house can be constructed to safely process chicken for farmers before sale to buyers who require dressed chicken (Fisseha *et al*, 2010).

Scholars reported that traders can bulk chicken from farmers, buying at farm gate price and re-selling at a margin to organized markets. Operators can take advantage of the organized value chain to transport chicken, eggs and inputs to and from farmers. These, among others are significant opportunities in the poultry value chain that shrewd business operators can take advantage of. It is however important to increase the production of chicken first to meet the required demand to be able to jumpstart the other related poultry businesses (Vernooij *et al*, 2016).

Literatures have shown that indigenous chicken offers a low investment start-up enterprise to farmers and does not require a lot of space. The birds are more tolerant to harsh conditions and diseases than commercial breeds and can be fed on cheap, locally available feeds or free forage, with minimal care. These varieties present employment opportunities and income to women, youth and the rural poor, with a ready local market. Furthermore, the indigenous poultry industry has a recognized potential to generate higher income and transform living standards if appropriate interventions such as improved genetics, better feeding, housing and management for more meat and eggs are developed and implemented. The benefits of indigenous chicken to rural households are potentially quite high, yet the industry has not been adequately supported. In many African countries, for example, the sector remains in its infancy (FAO, 2012).

References have shown that the value chain presents many other untapped opportunities, such as agro input suppliers, hatcheries, breeding farms, vaccine producing firms, improved feed manufacturers, manure aggregation, slaughtering, processing and improved housing equipment. Others include secondary bulking and transportation which may take the form of village-based and trading route-based brokers. Transportation to various retail outlets such as supermarkets and franchise outlets, chicken abattoirs as well as the

growing hospitality industry all present strong opportunities for growth and investment. Support is needed from governments, the private sector, research institutions, the donor community and other stakeholders to develop this promising sector and capture the immense value opportunities at hand (ILRI,2014).

## Challenges of Poultry Value Chain in Ethiopia

References have shown that the poultry value chain enabling environment has not yet conducive enough. The poultry value chain tax system (import of essential inputs) needs streamlining; food safety regulations need to be enforced. There is still a strong role to play for lobbying bodies such as the Ethiopian Poultry Producers Association (EPPA). Ethiopian import regulations can be quite a challenge. To import breeding stock farmers need to apply for an import permit at the Ministry of Agriculture. With this permit the farmer needs to arrange a letter of credit at the bank. The shortage of Foreign exchange and the often contradictory terms of conditions are often delaying this process. Currently there is no consistent supply of feed in adequate amounts, no regular and reliable supply yet of basic housing equipment, poor veterinary services and there is an insufficient knowledge base (FAO, 2014).

There is a chronic shortage of day old chicks in Ethiopia. This leads to many farmers abandoning poultry keeping because their poultry houses will often be empty for months on end whilst they are waiting for new supplies from the hatcheries. Although the available hatching capacity is adequate, its performance is rather poor and needs improvement. For the government (MOA of Ethiopia), for poultry associations and poultry producers, it is of importance to understand the economic impact of poultry diseases. Capacity building is still needed for disease monitoring, epidemiology and diagnostic skills (CSA, 2014).

## SWOT Analysis and their evidences for Poultry Value Chain in Ethiopia

SWOT analysisis aprocess that identifies an organization's strengths, weaknesses, opportunities and threats. Specifically, SWOT is a basic, analytical framework that assesses what an entity (usually a business, though it can be used for a place, industry or product) can and cannot do, for factors both internal (the strengths and weaknesses) as well as external (the potential opportunities and threats). Using environmental data to evaluate the position of a company, a SWOT analysis determines what assists the firm in accomplishing its objectives, and what obstacles must be overcome or minimized to achieve desired results: where the organization is today, and where it may be positioned in the future poultry SWOT analysis in both developed and developing countries including Ethiopia (USAID, 2006).

*A/Strength:*

Our strength as a commercial poultry farm and egg production company is the fact that we have healthy relationships with loads of major players (agriculture merchants) in the industry; both suppliers of poultry feeds and medications and buyers of chickens and eggs within and outside of the country (USAID, 2006).

We have some of the latest commercial poultry farming hatchery, tools and equipment that will help us raise and produce eggs in commercial quantities with less stress. Aside from our relationship (network) and equipment, we can confidently boast that we have some the most experienced hands in Ethiopia (USAID, 2006).

*B/Weakness:*

Our weakness could be that we are a new commercial poultry farms and egg production company in the country, and perhaps it might take us sometime to attract big time customers in the industry. We are aware of this and from our projection will overcome this weakness with time and turn it to a major advantage for the business in Ethiopia (USAID,

2006).

*C/Opportunities:*

The opportunities that are available to us as a standard commercial poultry farm and egg Production Company cannot be quantified, we know that there are loads of households, and businesses such as hotels and fast food restaurants that can't do without daily supply of chicken and eggs.We are well positioned to take advantage of this opportunity in Ethiopia (USAID, 2006).

*D/Threat:*

Some of the threats and challenges that we are likely going to face when we start our own commercial poultry farm and egg production company are global economic downturn that can impact negatively on household spending, bad weather cum natural disasters (draughts, epidemics), unfavorable government policies and the arrival of a competitor (a commercial farm that engage in the rearing of chickens and other birds) within same location.There is hardly anything you can do as regards this

**Scenario 2.Poultry SWOT analysis in Ethiopia**




**Figure 6:** SWOT Analysis of poultry in Ethiopia

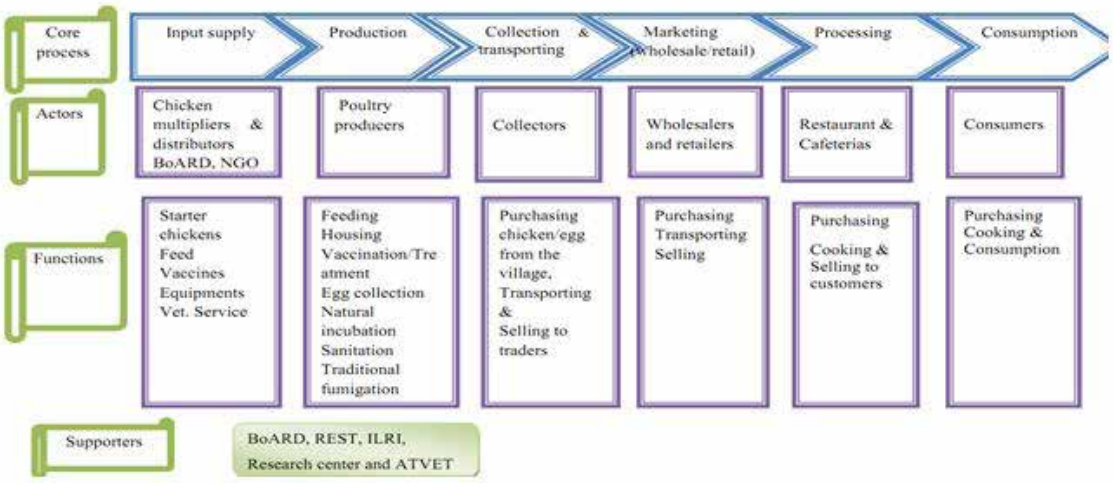



**Figure 7:** Poultry value chain mapping in Ethiopia

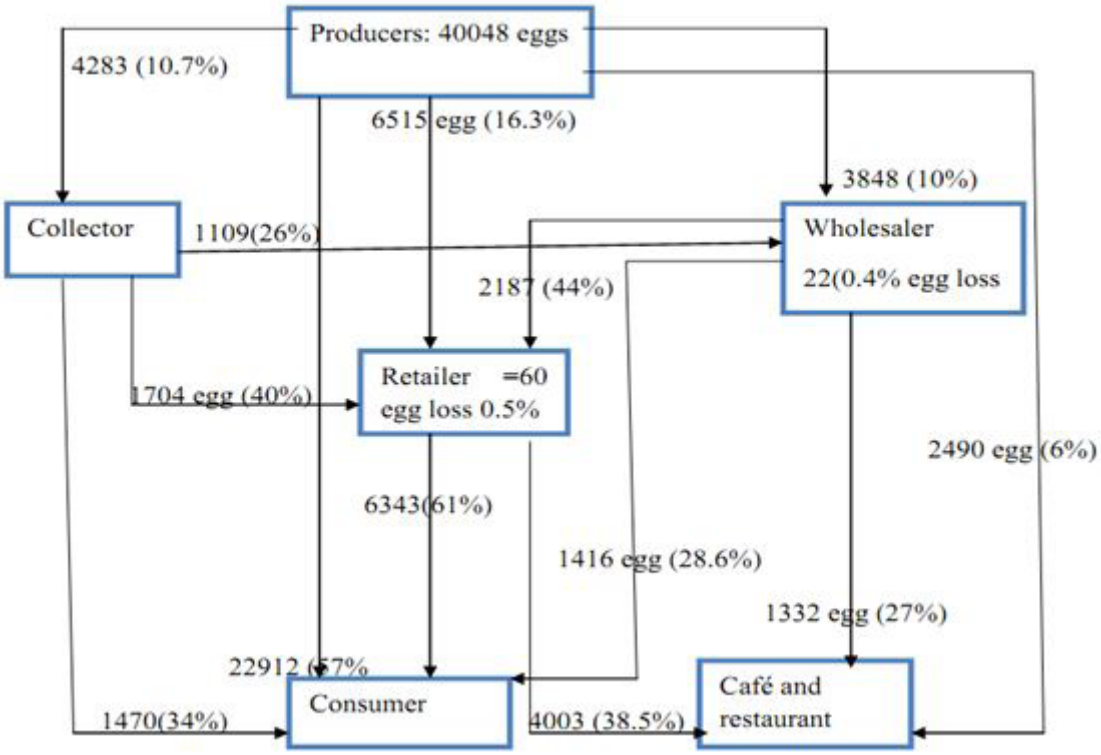



**Figure 8:** Value chain map of poultry in some farming areas of Ethiopia

threats and challenges other than to be optimistic that things will continue to work for your good in Ethiopia (USAID, 2006).

## Conclusion

References also disclosed that the total chicken population in Ethiopia has increased and estimated to reach above 59.5 millions. Moreover; it has also been reported that village chicken production account above 90% of the total chicken production where exotic and hybrid chicken constitutes above 10% of the chicken production in the country.

The overall implication of the review has shown that in poultry value chain actor and linkages remained yet not to be strong at both national and regional level. The awareness of the poultry producers towards the poultry production and market system is still not adequately addressed because of inefficient promotion works at all levels of the poultry value chain. Poultry business at commercial level is not as simple as selling chickens and collecting eggs and before establishing the farm good input and output market research has to be made. Which means availability of day old or three month chicken, vet service and, feed must be ensured to buy down the risk before opening farm and made profitable business. No one should start commercial poultry farm without adequate skill and expertise and deprived of ensuring availability of proper veterinary service and feed in the locality.

Therefore, there is a need for intervention designed for improving backyard and commercial poultry market system in all value chain areas through integrated effort of public and private sector cooperation. Support the establishing of breeding centers and leveraging on regional private commercial farm to improve the input supply and market information of poultry production will be imperative. By so doing, it is possible to address constraints on production technologies, input supply and product marketing systems along the poultry value chain and possible to shift subsistence production to market-oriented production system in the country as a whole

## Recommendation

Establishing Regional Breeding center can expand commercializing and expansion of poultry production at national and regional level. The regional pastoral area development offices need to give attention and make this to happen:

- Strengthen and train Private and governmental poultry producer to improve poultry chain actors and provide poultry bio-security measures.
- Work with public service providers to sensitize community and facilitate awareness creation on the benefits of poultry production, feed and vet service
- Encouraging and support more than one commercial poultry farm in each cluster that can play significant role in supply of three-month-old chickens and processed poultry feed to communities
- Strengthen the awareness level of community through private sector actors to upgrade the skill and techniques of production and consumption (Nutritional aspect) of poultry in the market system
- Sensitize the government for improving infrastructures in urban and rural areas and ease access to get electricity, land and water etc. for private actors who are in the business and for new entrants
- Business coaching for small and medium poultry farms to rethink their business model and expand their outreach and market to potential poultry producing areas
- Facilitate training in collaboration with big commercial farms and institutes Universities and research institutes who are engaged in poultry business with less business and technical skill
- Relevant government agencies should support in verifying the breeds brought from Hatcheries and big farms for quality and viable breeds. Research centers should identify which breed is adaptable to the niche area Poultry base initiated projects need to work in a bilateral basis and provide training to producer group on

importance of make use of the value chain to enhance profitability along with the full satisfaction of the customers of the whole poultry value chain

- Governmental and nongovernmental research institutes and universities should work in collaborative basis to undergo SWOT analysis along the poultry value chain and adequately consult policy makers in the country

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# PREVALENCE OF FOOT ABNORMALITIES IN SMALL RUMINANTS IN BAUCHI METROPOLIS

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## Abstract

A study was carried out to investigate the prevalence of lameness in small ruminants (sheep and goats) in Bauchi metropolis, Nigeria. A total of 1885 small ruminants were examined between July to September 2014 and November to January 2015 out of which 307 (16.30%) showed signs of lameness. The common conditions encountered during the study included: Foot rot, interdigital pouch inflammation, tick bite dermatitis and traumatic injury to the limbs. Tick bite dermatitis ranked highest with 140 (45.60%) cases while the least result was recorded in traumatic injury 51 (16.61%). Lameness was highly significant (P<0,001) in ovine 208 (67.80%) than in caprine 99 (32.20%). Females were more severely infected with 187 (60.90%) cases than males 120 (39.10%) cases. There was no significant difference in lameness with respect to sex of small ruminants. Lameness was highly significant with respect to breed (P<0.001). Yankasa were more severely infected 141 (45.90%) and the least prevalence was obtained in Sudanese 8 (2.60%). Goats were moderately infected with a higher occurrence in the Sokoto red goat 79 (25.70%) and the least result was recorded in Borno white 6(2.0%). Prevalence of lameness was highly significant (P<0.001) in the wet season 233 (75.90%) than in the dry season 74 (24.10%). There was a highly significant difference (P<0.001) in lameness with respect to management system. The highest occurrence of lameness 194 (63.20%) was found in semi intensively managed flocks, and the lowest result of 26 (8.50%) was obtained in intensively managed flocks. It is pertinent that thorough and effective diagnosis and management of lameness be conducted adequately so that the conditions can be put under control to obtain increased productivity of sheep and goats in Nigeria.

**Keywords:** Lameness, tick bite dermatitis, inflammation, foot rot, interdigital pouch, caprine

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## Introduction

Nigeria has copious livestock resources with an estimated population of 14,000,000; 32,000,000; and 34,000,000 cattle, sheep and goats respectively (NLR, 1992). The contribution of livestock to the overall food output in developing countries is increasing faster than that of cereals. In 1990, meat production increased from 69 million tonnes to about 105 by the year 2000 (FAO, 2003). In developing countries, consumption of meat has been growing at the rate of 5-6% per year while that of milk and dairy products at 3-4% per year. The domestic species of sheep and goats are major sources of food and fibre and they play very significant social and economic roles in the developing countries. Sheep and goat secondary functions include the production of milk, wool, skin and manure (Orshkov, 2001). Meat from sheep and goats has a consumer demand particularly during religious festivals and cultural celebrations for the small holder farmers in sub-Saharan Africa (ILCA, 1987). In most developing countries, they serve as insurance in case of crop failure (Peacock, 1996).The productivity of sheep and goats is low due to increased disease conditions which constituted a major problem. Other factors include poor management, inadequate nutrition (quantity and quality), high neonatal mortality, poor genetic potential and low level of literacy among farmers. (David West, 1989). Clinical lameness of small ruminants causes adverse changes in welfare of the individual animal or the flock and health is an integral part of the welfare of animals (caroprese *et al*., 2009). Lameness results in significant reduction in the productivity of these livestock (Clarence *et al*., 1991). Lameness leads to reduced performance due to decreased feed intake, diminished feed and reproductive efficiency, loss of body weight, lowered milk production and libido (Greenough, 1972; Harris *et al*.,1988). This paper examines the prevalence of foot abnormalities in small ruminants in Bauchi metropolis.

## Results

The prevalence of 16.30% among 1,885 sheep and goats were recorded.Table 1 shows percentage distribution of lameness according to limb conditions in sheep and goats, with the highest occurrence 140 (45.60%) out of the 307 cases of lameness as tick bite dermatitis, moderate occurrence was foot rot 62 (20.20%), followed by interdigital pouch inflammation 54 (17.59%) and the least occurrence was traumatic injury 51 (16.61%) as shown in (plates I to iv). Distribution of lameness in relation to species of sheep and goats, the result indicated that lameness was highly significant (P<0.001) in ovine 208 (67.80%) than caprine 99 (32.20%) (Table 2). There was no significant difference of lameness in relation to sex of sheep and goats studied (Table 3). There was significant (P<0.001) difference of lameness among the breeds of small ruminants. Yankasa was more severely infected 141 (45.90%) compared to Balami 28 (9.10%), followed by Uda 20 (6.50%) and the least result was obtained in Sudanese 8 (2.60%). Goats were moderately infected with the highest occurrence in red Sokoto goats79 (25.70%), followed by the Kano brown goat 10 (3.30%) and the least was Borno white goat 6 (2.0%) (Table 4). There was also a significant difference (P<0.001) between lameness and season. The highest prevalence of lameness 233 (75.90%) was recorded in wet season while the lowest prevalence of lameness 74 (24.10%) was recorded in the dry season (Table 5).There was significant (P<0.001) difference of lameness with respect to management system with highest occurrence 194 (63.20%) found in semi-intensively managed flocks (Table 6).

**Table1:** Distribution of Lameness in Sheep and Goats

| Types of Lameness | No. Positive | % Positive |
|---|---|---|
| Tick bite dermatitis | 140 | 45.60 |
| Foot rot | 62 | 20.20 |
| Interdigital Pouch inflammation | 54 | 17.59 |
| Traumatic Injury | 51 | 16.61 |
| **Total** | **307** | **100** |

**Table 2:** Distribution of lameness in relation to species of Sheep and Goats

| Species | No. Positive | % Positive | |
|---|---|---|---|
| Caprine | 99 | 32.20 | |
| Ovine | 208 | 67.80 | $X^2$ =78.664 |
| **Total** | **307** | **100** | |

*Key: ***=significant (P<0.001)*

**Table 3:** Distribution of Lameness in relation to sex of Sheep and Goats

| Sex | No. Positive | % Positive | |
|---|---|---|---|
| Male | 120 | 39.1 | |
| Female | 187 | 60.9 | $X^2$ = 2.361 |
| **Total** | **307** | **100** | |

*Key: ns = not significant*

**Table 4:** Distribution of lameness in relation to the Breed of Sheep and Goats

| Breed | No. Positive | % Positive | |
|---|---|---|---|
| Yankasa | 141 | 45.9*** | |
| Uda | 20 | 6.5 | |
| Balami | 28 | 9.1 | |
| Sudanese | 8 | 2.6 | |
| Sokoto | 79 | 25.7 | X=93.129 |
| Borno White | 6 | 2.0 | |
| Kano Brown | 10 | 3.3 | |
| West African Dwarf | 15 | 4.9 | |
| **Total** | **307** | **100** | |

*** = *Significant (P<0.001)*

**Table 5:** Distribution of Lameness in relation to season

| Sex | No. Positive | % Positive | |
|---|---|---|---|
| Dry | 74 | 24.1 | |
| Wet | 233 | 75.9 | $X^2$=107.836 |
| **Total** | **307** | **100** | |

****significant = (P<0.001)*

**Table 6:** Distribution of Lameness in relation to Management system

| **Management System** | No. Positive | % Positive | |
|---|---|---|---|
| Intensive | 26 | 8.5 | |
| Extensive | 87 | 28.3 | |
| Semi Intensive | 194 | 63.2 | $X^2$ = 47.758 |
| **Total** | **307** | **100** | |

****significant = (P<0.001)*



**Plate i(a):** Lameness in sheep (the ticks are attached to the interdigital space, making it inflamed and swollen).



**Plate ii:** The plate is showing foot rot in sheep. It includes under running of the hoof horn. This occurs when pastures or housing floors have been consistently wet with no dry spells.



**Plate i(b):** The plate is showing tick bite dermatitis in a goat.



**Plate iii(a):** This is interdigital pouch inflammation. The interdigital space is inflamed with white grey pasty exudates.



**Plate iii(b):** Again this is interdigital pouch inflammation. The interdigital space is inflamed with red, moist interdigital skin.



**Plate iv:** Traumatic injury to the foot of a sheep

## Discussion

The prevalence of 16.30% among 1,885 sheep and goats from which 307 were found to be infected with different foot conditions was high. This finding is in line with the report by Bokko and Chaudhari, (2001). Tick bite dermatitis showed the highest occurrence of 45.60% followed by foot rot 20.20%, interdigital pouch inflammation 17.59% and the least was traumatic injury 16.61%. The characteristic short rainfall, long dry season, tough rugged terrain and pricking or abrasive vegetation especially in wet conditions and the long distances these animals cover in search of feed in semi intensively and extensively managed flocks predispose them to lameness due to tick bite dermatitis, foot rot, interdigital pouch inflammation and other foot conditions as observed in this study. Similarly, wetness, unkempt hoof, penetrating injuries, fractures, inflammation of anatomical structures and glands are reported to be predisposing factors to lameness in small ruminants (Winter, 2006).

The distribution of lameness in this study indicated highly significant difference ($P<0.001$) in ovine 67.80%. This finding is in accord with (Lynn *et al*., (2009) who reported a similar trend. This may be due to the fact that animals with rapid hoof growth and in an overgrown condition were more susceptible to foot diseases. The occurrence of lameness was Plate iv: Traumatic injury to the foot of a sheep less in caprine, this may be due to the hardy nature, relative phobia for rain and wet environments and feeding behavior of these animals (West, 1983). However, West (1983) further reported that the chances of mechanical injury and foreign body penetration in the feet of goats do increase while they stand on two hind limbs. Females were more severely affected 60.90% than males 39.10%. There was no significant difference in lameness with respect to the sex of small ruminants. Lameness was highly significant among breeds of sheep ($P<0.001$) with the Yankasa being more severely infested. This is probably due to the predominance of the breed kept by the flock's owners, because of their high market value. The least prevalence was obtained in Sudanese sheep. Goats were moderately to severely infected with a higher occurrence of lameness in the Sokoto red goat followed by the West African dwarf, the Kano brown and the least result was recorded in the Borno white goat breed.

Lameness was highly significant ($P<0.001$) in wet season with higher prevalence of 75.90% while prevalence of 24.10% was recorded in dry season. This is because insect proliferation increases in rainy season which lead to increase number of ticks. When sheep are grazed or kept under a continuously wet environment, it may lead to softening of

the horny tissue of the claws; this stimulates destruction of the hoofs, breakage and fissure of horny tissue exposing the sensitive lamina resulting in foot rot (Winter, 2006). Lameness mostly occurs during the wet season and in locations where sheep and goats commonly congregate such as feeding sites and watering areas (Lynn *et al*., 2009).

There was a highly significant difference ($P<0.001$) in lesions with respect to management systems in sheep and goats. The management system as observed in this study contributes considerably to the occurrence of lameness in small ruminants. The highest occurrence of lameness of 63.20% was found in semi intensively managed flocks, a moderate occurrence of lameness 28.30% was found in extensively managed flocks and lowest result 8.50% was found in intensively managed flocks. Extensive and semi intensive systems of management characterized by long distance trekking which these animals need to cover in search of feed together with the adverse effects of a tropical climate such as rainfall, exposure to high ambient temperatures, relative humidity etc. may predispose these animals to many lameness conditions. As observed in this study, in all the flocks examined, there was absence of prophylaxis such as animal bathing, foot baths, vaccination etc. Sheep and goats are gregarious, that is, they prefer to cluster together. The tendency of these animals to cluster together facilitates the spread of diseases such as foot rot.

## Conclusion

It could therefore be concluded that season, breed and management systems contribute considerably to the occurrence of lameness in small ruminants in this environment. Furthermore there was absence of routine prophylaxis such as foot baths, animal bathing/ dipping and vaccination

## Recommendation

It is pertinent that thorough and effective diagnosis and management of lameness be conducted adequately so that the conditions can be put under control to obtain increased productivity of sheep and goats in Nigeria.

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# PREVALENCE OF *Bovine* OF *Schistosomosis* IN AND AROUND NEKEMTE, EAST WOLLEGA ZONE, WESTERN ETHIOPIA

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## Abstract

A cross-sectional study was conducted from March, 2016 to May 2016 at Guto Gida District, Nekemte, Ethiopia to determine the prevalence of *bovine schistosomosis*. Simple random sampling method was used to select the study animals and sedimentation technique was applied for finding of Schistosoma eggs from fresh fecal samples. Out of 384 fecal samples examined, 22 were found positive indicating an overall prevalence of 5.7% *schistosomosis* in the study area. The prevalence of *bovine schistosomosis* was higher in Jirenga kebele (9.1%) than Gaarii kebele (4.6%) and Dalo kebele (3.7%). However, no statistically significant difference in the prevalence of *bovine schistosomiasis* in relation to origin was found. Similarly, there was no statistically significant difference observed between both sexes (P>0.05). The prevalence in body condition category was reported relatively higher in poor body condition (8.4%) and lower in good body condition (3.8%). However, no statistically significant differences appreciated among the three body condition categories (P>0.05). The finding indicated that, *schistosomosis* should be taken into consideration as one of the major limiting factor to livestock productivity at Guto Gida District. The control measures against *schistosomosis* must be designed to target either the parasite or the snail intermediate host.

**Key words:** *bovine*, Guto Gida, prevalence, *schistosomiasis*

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## Introduction

*Schistosomosis* is an infection which occurs due to trematodes of *genus schistosoma*. The disease, characterized by its chronic nature and affects the productivity and production performances and predisposes animals to other diseases in the World (Mc- Cauley *et al*., 2000), and it is endemic in the tropical and subtropical countries of Africa, Asia and Southern Europe (Lawerence, 2001).

Epidemiological studies on *bovine schistosomosis* are suggestive of the endemicity of the infection particularly in areas with large permanent water bodies and marshy pasture areas. In Ethiopia, the optimum range for distribution of S. mansoni has been reported as 1500 to 2000 meter above sea level (masl) (Gashaw, 2010). Schistosoma bovis has a localized distribution which found commonly in Northern, Eastern, South Western and central parts of Ethiopia (Fekade *et al*., 2002); It is affecting all ages of animals and mainly prevalent in cattle kept around lakes and rivers (Dwight *et al*., 2003; Pitchford, 2006).

*Schistosomosis* transmitted by using snails as an intermediate host, the immature infective form penetrates the skin of the host and may also infect cattle by ingestion through drinking water (Allen *et al*., 2002; Lindbergh *et al*., 2006). Animals affected by the disease show different clinical signs such as diarrhea, sometimes blood stained and containing mucus, and also anorexia, thirst and emaciation is the sign shown by animals with disease (Gutierrez, 2004)

Diagnosis of the disease is primarily based on the history of schistomosis in the area and the identification of snail habitats with history of access to natural water bodies (Bedarkar *et al*., 2000; Pawar *et al*., 2016). Postmortem examination, hematological tests and examination of feces for schistosoma eggs are also useful .The clinical signs alone will not sufficient to arrive definitive diagnosis but, it should be used to indicate the necessity of feces examination, which reveals the eggs of parasites mixed with blood and mucous (Thrusfied, 2005).

For treating the disease, older drugs include antimonial preparation, tartar emetic, antimosan and stibophen, niridirozole and trichlorphon. Praziquantel, which is a drug of choice for treatment of human *schistosomosis*, is also effective in ruminants at 15-29 mg/kg, peros (Gracia and Bruckner, 2007).

The effective control of the disease is to prevent contact between the animals and the parasite by fencing of infected waters and supplying clean water and also by the destruction of intermediate host or snails (Hansen and Perry, 2004). Even though, *schistosomiasis* is an economically important disease of livestock leading huge economical losses, due to morbidity and mortality and thereby contributing to productivity loss, there is no considerable work done on the prevalence of the disease in and around Nekemte.

Therefore, the objective of this study was: - to determine the prevalence of *Schistosomiasis* in cattle in Nekemte area.

## Materials and Methods

*Study area*

The study was conducted from March to May, 2016 in Guto Gida district, Nekemte town, East Wollega Zone of Oromia Regional state, Ethiopia. The district is about 331 km from Addis Ababa to the West. The area has average temperature of 200C, mean annual rainfall 21500mm. The altitude of the area ranges from 1300-3140m a.s.l.According to the Nekemte district Agricultural office, Livestock population of cattle in head is 85,584, sheep 14,702, Goat 11,861, Equine 98,674, chicken 94,276 and mixed crop and livestock farming system is the mode of agriculture in the district in which cattle and sheep as a major livestock, which are highly important for livelihood of the local population (NWAROD, 2016).

*Study population*

The study population was cattle with different age groups, body condition and sex. The age of animal was determined based on dentition (Pope, 2008) and the body condition

Prevalence of *Bovine* of *Schistosomosis* in and Around Nekemte, East Wollega Zone, Western Ethiopia 631 of the animals was classified into three groups:- poor, medium and good based on visibility of skeleton by inspectional examination (Debont *et al*., 2005).

*Study design*

A cross sectional study was used to determine the prevalence of *bovine schistosomosis* and its risk factors at Nekemte area from March to May, 2016.

*Sampling and sample size determination*

From area of Nekemte town the Kebeles (Jirenga kebele, Gaari kebele and Dalo kebele) were selected by purposive sampling based on animal population of the Kebeles and consideration of the representativeness.

The desired sample size was determined by using the formula given by (Thrushfield, 2004), and with 95% confidence level 5% desired absolute precision and since there was research conducted in this area, 50% expected prevalence was taken.

$$\frac{N=1.96*P_{exp}\ (1_{-Exp})}{d^2}$$

whereas:-
n=required sample size
$p_{exp}$= prevalence
$d^2$= Desired absolute precision.

$$\frac{N=1.96*0.5(1-0.5)}{(0.05)}$$
$$=384$$

Accordingly, animals were selected randomly to estimate the prevalence of the infection in the study area.

## Study method and cample collection

*Coproscopic Examination*

Fresh fecal samples were collected directly from the rectum of randomly selected animals and preserved in 10% formalin in universal bottles to prevent hatching of miracidia. Then eggs were examined by fecal sedimentation techniques and observed under microscope in the laboratory (Ash and Orihel, was no statistically significant difference on the prevalence of *bovine schistosomosis* based on three PAs ($p>0.05$) as indicated in Table 1.

*Prevalence based on sex*

The study indicated that, the prevalence of *bovine schistosomosis* in male and female was 6.9% and 4.5%, respectively. Although the prevalence was relatively higher in female as indicated in Table 2 the difference was not statistically significant ($P>0.05$).

*Prevalence based on body condition*

Prevalence of *bovine schistosomosis* on poor body condition animals was 8.4% and medium body condition (5.1%). However, animals with good body condition showed prevalence of 3.8%. As described in Table 3, significant difference ($P > 0.05$) was not observed among body condition of the study animals for the occurrence of *schistosomosis*.

*Prevalence based on age*

According to the age of animal, the prevalence of *schistosomosis* varied. Low prevalence was observed in young animals (4.9%), and the highest prevalence was observed in adult animals (6.2%). However, there was no significant difference ($P > 0.05$) among age groups.

## Discussion

The overall prevalence of *bovine schistosomosis* infection of the study area was found to be 5.7%. When this result is compared with the prevalence of other authors in the country it is much lower than the finding of Mersha *et al*., (2012) which was 13.7 % in Fogera. Similarly, 22.06% was reported in and around Bahir Dar (Solomon, 2008) and 27.13% in Dembia (Alemseged, 2010). The difference in prevalence may be due to the variation in the study seasons, sample size, humidity, management and climate change between various agro-ecologies. The present study nearly similar with that of Mihret and Samuel, 2015

**Table 1:** Prevalence of *bovine schistosomosis* based on PAs or kebeles.

| PAs or Kebeles | No examined | No infected | Prevalence (%) | $X^2$ | P value |
|---|---|---|---|---|---|
| Garii | 129 | 6 | 4.6 | | |
| Jirenga | 120 | 11 | 9.1 | 3.928 | 0.055 |
| Dalo | 135 | 5 | 3.1 | | |
| **Total** | **384** | **22** | **5.7** | | |

**Table 2:** Prevalence of *bovine schistosomosis* based on sex

| Sex | No examined | No infected | Prevalence (%) | $X^2$ | P value |
|---|---|---|---|---|---|
| Male | 187 | 13 | 6.9 | 1.009 | 0.382 |
| Female | 197 | 9 | 4.5 | | |
| **Total** | **384** | **22** | **5.7** | | |

**Table 3:** Prevalence of *bovine schistosomosis* based on body condition.

| Body condition | No examined | No infected | Prevalence (%) | $X^2$ | P value |
|---|---|---|---|---|---|
| Poor | 119 | 10 | 8.4 | 2.503 | 0.073 |
| Medium | 135 | 7 | 5.1 | | |
| Good | 130 | 5 | 3.8 | | |
| **Total** | **384** | **22** | **5.7** | | |

**Table 3:** Prevalence of *bovine schistosomosis* based on body condition.

| Age | No examined | No infected | Prevalence (%) | $X^2$ | P value |
|---|---|---|---|---|---|
| Young | 161 | 8 | 4.9 | 0.297 | 0.661 |
| Adult | 223 | 14 | 6.2 | | |
| **Total** | **384** | **22** | **5.7%** | | |

(7.6%) in and around Debre Tabor town, South Gondar Zone of Amhara region, Northwestern Ethiopia; this can be due to similar management in the areas.

The relatively greater prevalence of the disease was in Jiregna and Gaarii PAs. May be due to swampiest and moisture nature of most of the grazing areas in these PAs. Similarly many authors also reported that water lodged and poorly drained areas with acidic soils are often endemic for *schistosomosis* (Almaz, 2007). Mihret and Samuel (2015) also reported that there was difference of *bovine schistosomosis* prevalence based on origin but there was no significant difference between origin and the infection.

The higher prevalence of *bovine schistosomosis* was in adult animals in this study agrees with the work of (Alemseged, 2010), who reported a prevalence of 17.6% in Young animals and 30.10% adults in Dembia district and disagrees with the work of (Taylor *et al*., 2007) who reported highest prevalence in young animals.

The variation in the prevalence was found (6.9%) in male and (4.5%) in female revealed no statistically significant (P>0.05) difference. This variation is similar with previous study which was 29.61% in male and 19.54% in female (Solomon 2008), in and around Bahir Dar and 30.70% in male and 23.30% in female (Alemseged 2010) in Dembia district. The study was disagrees with the study conducted by Mihret and Samuel (2015) and found higher prevalence in female (33.1%) and lower in male (27.1). The results indicated that both sexes have the same risk to acquire disease. This is because of equal exposure to the risk factors

since there were no restrictions on movement for grazing and contact with the parasite and animals in terms of sex. This exacerbates the multiplication of Schistosoma and increases the epidemiology of the disease; also reported that the increased contact time with Schistosoma infested habitat increases the rate and endemicity of *schistosomosis*.

Schistosoma infection rate in relation with body condition score in the present study was varied in cattle. Animals with poor body condition score were more affected than other groups of animals. Similarly Merawe *et al*., (2014) affirmed that the infection rate increase with animals which have poor body condition score. This could be due to that acquired immunity status of poor body condition and weak animals become more suppressed and susceptible which might be due to malnutrition and other parasite infection. So, infected animals may require long period of time to respond against Schistosoma infection. This gives suitable time for establishment and fecundity of the parasite in animals.This finding also coincides with the work of Belayneh and

Tadesse (2014) that accounted the prevalence of Schistosoma more common in animals with poor body score animals than medium and good body condition.

## Conclusion and Recommendation

According to the present study the overall prevalence of *bovine Schistosomosis* was found to be 5.7% in and around Nekemte. The study also revealed that the prevalence of *schistosomosis* is high in Jirenga and followed by Gari peasant associations. The prevalence of the disease is also closely linked with environmental factors those are suitable for the development and multiplication of snail which is intermediate hosts and the parasite. Therefore, depending on the result of the study the following recommendations are forwarded:

- There should be initiation and awareness creation on the prevention and control of snails.
- Further epidemiological investigations should be conducted to assess the Schistoma infection and its associated risk factors.
- There should be regular deworming and Veterinary service in the study area.
- Grazing management should be involved to avoid grazing around marshy area in which snail population is high.

## Authors' Contributions

Abriham Kebede and Jiregna Dugassa designed the methodology and created the survey instrument, drafting and writing of the manuscript and analyzed the data. Others have participated in the data collection, whereas; Abriham Kebede again contributed to reviewing the manuscript to be ready for publication. All authors read and approved the final manuscript.

## Competing interest

The authors declare that they have no competing interest

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# REVIEW ON THE RELATIONSHIP OF CLIMATE CHANGE AND PREVALENCE OF ANIMAL DISEASES

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## Abstract

Climate change is a subset of the larger set of ecosystem change that is promoting the emergence and re-emergence of animal diseases. It affects livestock health through several pathways. These includes effects on pathogens, such as higher temperatures affecting the rate of development of pathogens or parasites; effects on hosts, such as shifts in disease distribution that may affect susceptible animal populations; effects on vectors, such as changes in rainfall and temperature regimes that can affect both the distribution and the abundance of disease vectors; and effects on epidemiology, including altered transmission rates between hosts, food safety and animal production. Furthermore, Climate change influences the emergence and proliferation of disease hosts or vectors and pathogens and their breeding, development and disease transmission. Consequently, it affects distributions, host–parasite relationships and their assemblages to new areas. Indirectly the climate change can affect quantity and quality of fodder crops, animal production, severity and distribution of diseases in both domestic and wild animals that result in their migrations. Most developing countries are highly vulnerable to this climatic impact. Ethiopia faces recurrent droughts in its different regions that end in economic crises. Even though this climatic change causes different economic impacts in the country, little research has been conducted on it. Climate models suggest that Ethiopia will see a further warming of 0.7°C and 2.3°C by the 2020s and between 1.4°C and 2.9°C by the 2050s. It is therefore important to create public awareness on how climatic change can occur and result in high prevalence of infectious animal diseases that contribute to economic crises in the country.

**Key words:** climate change, disease transmission, host, pathogen, vector

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## Introduction

Agriculture remains the backbone of most African economies (Hussein *et al*, 2008). The agricultural sector is the largest domestic producer across the continent and employs between 70% and 90% of the total labor force (FAO, 2007). In addition, agriculture supplies up to 50% of household food requirements and up to 50% of household incomes. Most of the income is generated by beef cattle, dairy cattle, goats, sheep and chickens. Together these five species generate 92% of the total revenue from livestock in Africa. In many rural communities, livestock is the only asset of the poor, but it is highly vulnerable to climate variability and extremes (Thornton *et al*, 2007; IFAD, 2010). The impact of climate change is expected to heighten the vulnerability of livestock systems and reinforce existing factors that are affecting livestock production systems (Gill and Smith, 2008).

This climate change refers to long-term statistical shifts of the weather, including changes in the average weather condition or in the distribution of weather conditions around the average (IPCC, 2007). A warming and unstable climate is playing an ever-increasing role in driving the global emergence, resurgence and redistribution of infectious diseases. Three components are essential for most infectious diseases: an agent (or pathogen), a host (or vector) and transmission environment. Some pathogens are carried by vectors or require intermediate hosts to complete their lifecycle. Appropriate climate and weather conditions are necessary for the survival, reproduction, distribution and transmission of disease pathogens, vectors, and hosts. Therefore, changes in climate or weather conditions may impact infectious diseases through affecting the pathogens, vectors, hosts and their living environment (Epstein, 2001a).

This effect is by one (or a combination) of four primary mechanisms: the first is via range shifts in host or vector distribution that bring these hosts and vectors into contact with new animal populations; the second is through changes in the population density of the host or vector that would result in increased or decreased frequency of contact with animal or with other hosts and vectors; the third mechanism is via changes in the prevalence of infection by the pathogen in the host or vector population that would increase or decrease the frequency of animal contact with an infected host or vector; and the fourth is through changes in pathogen load brought about changes in rates of pathogen reproduction, replication, or development in hosts or vectors (Thomson *et al*., 2006).

The impact of climate change on livestock production and health in Africa is determined largely by the vulnerability of African livestock production systems (McCarty *et al*., 2001). From African tropical countries the potential impact of climate change on health has been recognized in Ethiopia, but developing specific actions and responses needed to mitigate its consequences need further work. Some impacts of climate change observed so far in the country are recurrent drought, flood, malnutrition and the re-emergence of climate-sensitive infectious diseases (FDRE, 2008).

A few researches have been conducted on the impacts of climate change on livestock health. Regardless of its vital importance in the country unfortunately, there are poor information on the relationship between long climate change and animal health. Monitoring its impact is a complex task since there are other confounding factors which may contribute to animal health problems.

Therefore the objective of this seminar paper is:

- To delineate the impact of climatic change on epidemiological triangles (pathogen, host and environment or disease transmission) that creates a window for animal diseases.
- To review and provide information on how climatic change can result in prevalence of animal infectious diseases.

## Climate Change and Prevalence of Animal Diseases

*Impact of Climate Change on Animal Health*

The distribution of infectious diseases,

the timing and intensity of disease outbreaks are often closely linked to climate. Climate change may affect livestock health through several pathways both direct and indirect. The direct effects of climate on animal health are likely to be most pronounced for diseases that are vector-borne, soil associated, water or flood associated temperature/humidity associated and sensitive to climate (Grace *et al*., 2015). These directly or indirectly effects by weather and climate may be spatial, with climate affecting distribution, temporal with weather affecting the timing of an outbreak, or relate to the intensity of an outbreak. Global climate change alters ecological construction which causes both the geographical and phonological shifts (Slenning, 2010). These shifts affect the transmission pattern of the pathogen and increase their spectrum in the hosts (Brooks and Hoberg, 2007).

The increased spectrum of pathogens increases the disease susceptibility of the animal and thus, supports the pathogenicity of the causative agent. The livestock systems are susceptible to changes in severity and distribution of livestock diseases and parasites as potential consequences. Incidence of external parasite (43.3%) was first ranked as the problems in the warm temperate (Dhakal *et al*., 2013). vector-borne diseases are especially sensitive to climate change. Changes in rainfall and temperature regimes may affect both the distribution and the abundance of disease vectors, as can changes in the frequency of extreme events. Arthropod vectors tend to be more active at higher temperatures; they therefore feed more regularly to sustain the increase in their metabolic functions, enhancing chances of infections being transmitted between hosts. Small changes in vector characteristics can produce substantial changes in disease (Grace *et al*., 2015).

A changing environmental spectrum also may result in increased or reduced contact between infected and susceptible animals and thus affect transmission. Temperature and humidity changes will also affect the spatial and temporal distribution of the pathogens of non-vector borne diseases that spend a period of time outside the host and are thus very sensitive to such changes. These pathogens include: the infective spores of anthrax and blackleg, the viruses causing peste des petits ruminants (PPR) and foot and mouth disease (FMD), contained in wind-borne aerosol droplets the agents causing dermatophilosis, haemorrhagic septicaemia, coccidiosis and haemonchosis (Morgan *et al*., 2007).

Anthrax is an acute infectious disease of most warm-blooded animals, including humans, with worldwide distribution. The causative bacterium, Bacillus anthracis, forms spores able to remain infective for 10-20 years in pasture. Temperature, relative humidity and soil moisture all affect the successful germination of anthrax spores, while heavy rainfall may stir up dormant spores. Outbreaks are often associated with alternating heavy rainfall and drought, and high temperatures (Parker *et al*., 2002).

Foot-and-mouth disease (FMD) is a highly contagious, viral infection of cloven-footed animals, including cattle, sheep and pigs. It is a major threat to the United Kingdom's (UK's) livestock and of considerable economic importance to Africa. Most transmission is by contact between infected and susceptible animals, or by contact with contaminated animal products. However, FMD can also spread on the wind. The survival of the virus is low at relative humidity below 60% (Donaldson, 1972), and wind-borne spread is favored by the humid, cold weather common to the UK. In warmer drier regions, such as Africa, wind-borne spread of FMD is considered unimportant (Sutmoller *et al*., 2003).

Peste des petits ruminant (PPR) is also another acute, contagious, viral disease of small ruminants, especially goats, which is of great economic importance in parts of Africa and the Near-East. It is transmitted mostly by aerosol droplets between animals in close contact. However, the appearance of clinical PPR is often associated with the onset of the rainy season or dry cold periods (Wosu *et al*., 1992), a pattern that may be related to viral survival. African horse sickness (AHS), a lethal infectious disease of horses, is caused by a virus

transmitted by Culicoides biting midges. Large outbreaks of AHS in the Republic of South Africa over the last 200 years are associated with the combination of drought and heavy rainfall brought by the warm phase of the El Niño Southern Oscillation (ENSO) (Baylis *et al*., 1999).

Rift Valley Fever (RVF), is another zoonotic viral disease of sheep and cattle that transmitted by Aedes and Culex mosquitoes. Epizootics of RVF are associated with periods of heavy rainfall and flooding (Davies *et al*., 1985) or, in east Africa, with the combination of heavy rainfall following drought associated with ENSO (Anyamba *et al*., 2002). ENSO–related floods in 1998, following drought in 1997, led to an epidemic of RVF (and some other diseases) in the Kenya/Somalia border area, causing the deaths of more than 2000 people and two-thirds of all small ruminant livestock (Little *et al*., 2001). Diseases transmitted by tsetse flies (trypanosomiasis) and ticks (such as anaplasmosis, *Babesiosis*, East Coast fever, heartwater) impose a tremendous burden on African livestock. Ticks, as ectoparasites, are a further direct burden. Many aspects of the vectors' life cycles are sensitive to climate, and spatial distributions can be predicted using satellite- derived proxies for climate variables (Rogers and Randolph, 1993)

*How Climate Change Affect Animal Diseases*

There is a substantial scientific literature on the effects of climate change on health and disease, but it has a strong focus on human health and vector- borne disease (Hay *et al*., 2002; Zell, 2004). By contrast, the effects of climate change on animal or non-vector-borne disease has received comparatively little attention (but with notable exceptions: Harvell *et al*., 2002). Given the global burden of diseases that are not vector-borne, and the contribution made by animal diseases to poverty in the developing world attention to these areas is overdue (Perry *et al*., 2002).

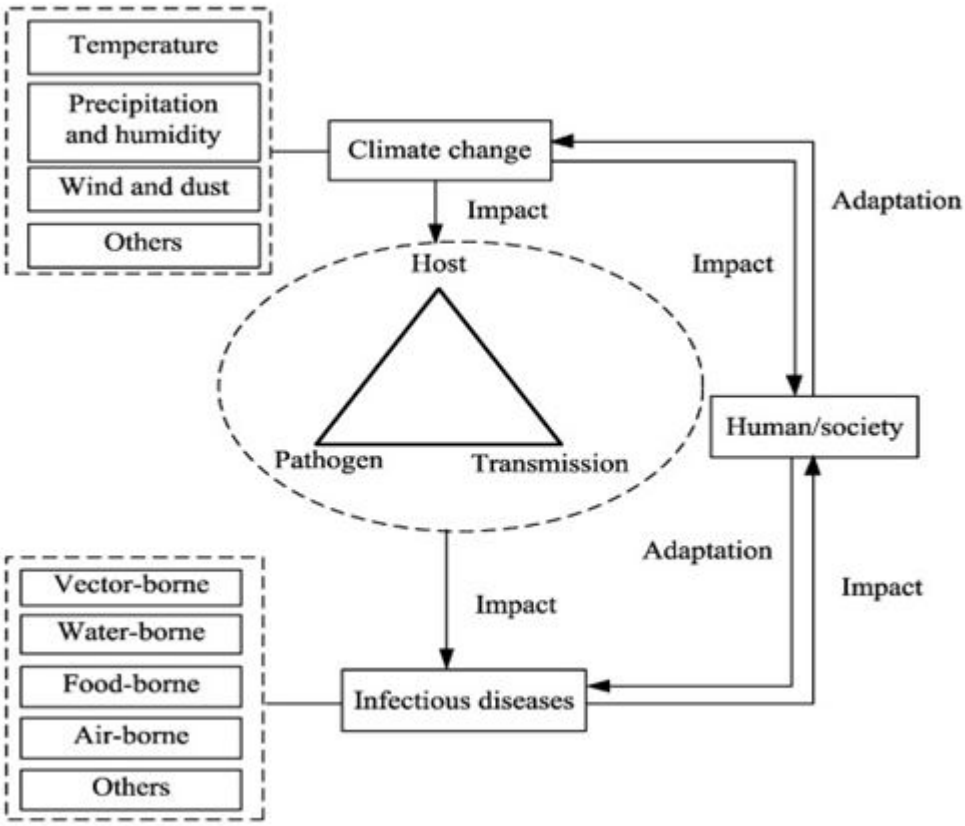
Many animal diseases of significant impact in the UK and Africa are influenced by climate. Such influences are not the sole preserve of vector-borne diseases. Indeed, certain directly transmitted, food/waterborne and aerosol-transmitted diseases are also affected. Additionally, climate appears to be more frequently associated with the seasonal occurrence of non-vector borne animal diseases than their spatial distribution. By contrast, the associations of vector-borne diseases with climate are equally apparent in time and space - a reflection of the strong influence of climate on both the spatial and temporal distributions of the intermediate vectors (Perry, 2002).

In the scientific literature many processes have been proposed by which climate change might affect infectious diseases. These processes range from the clear and quantifiable to the imprecise and hypothetical. They may affect pathogens/parasites directly or indirectly, the hosts, the vectors (if there is an intermediate host), disease transmission or the natural environment. Only some of these processes can be expected to apply to any single infectious disease (Harvell *et al*., 2002).

The first set describes the components of diseases: pathogen, host or vector, and disease transmission. The second set describes the climate and weather, including climate variables or large-scale extreme weather events. The third set describes the selected infectious diseases, including vector-borne, water-borne, air-borne diseases and food-borne diseases. (http://scholar.google.com), (http://www.sciencedirect.com/), (http://link. springer.com/) and CNKI (http://www.cnki. net/).

*Effect of Climate change on Pathogen*

Pathogen refers to a wide range of disease agents, including virus, bacterium, parasite germ, and fungi. The impact of climate change on pathogens can be direct, through influencing the survival, reproduction, and life cycle of pathogens, or indirect, through influencing the habitat, environment, or competitors of pathogens. As a result, not only the quantity but also the geographic and seasonal distributions of pathogens may change (Tian *et al*., 2015a). Temperature may affect disease through impacting the life cycle of pathogens. First, a pathogen needs a certain temperature range to survive and develop.




*Source: (http://scholar.google.com) ; (http: //www.sciencedirect.com); (http://link.springer.com/) and CNKI (http://www.cnki.net/).*

**Figure 1:** Climate change, animal infectious diseases, and human society

Excessive heat can increase the mortality rates for some pathogens. The extended periods of hot weather can raise the average temperature of water bodies and food environment, which may provide an agreeable environment for microorganism reproduction cycles and algal blooms, For example, salmonella species (Frank *et al*., 2006).

Salmonellas are a food-borne disease; the reproduction of the bacteria increases as temperature rises in that range between 7°C and 37°C. Lastly, rising temperature may limit the proliferation of other pathogen through favoring its competitors. For example, Campylobacter species, the bacteria of food-borne disease Campylobacter, was found to be more concentrated in surface water at low temperature and during winter it is believed that warmer temperature supports other bacteria to out compete Campylobacter species. And that ultraviolet light prohibits the survival of Campylobacter (Obiri-Danso *et al*., 2001).

Climate change may also cause shifts in precipitation, which affects the dissemination of water-borne pathogens, while rainfall plays an important role in the development of water-borne disease pathogens. Rainy season is related to the increase of fecal pathogens as heavy rain may stir up sediments in water, leading to the accumulation of fecal microorganisms, However, unusual precipitation after a long drought can result in an increase of pathogens, causing a disease outbreak. Droughts/low rainfall lead to Low River flows, causing the concentration of effluent water-borne pathogens (Hofstra, 2011).

Humidity change also impacts the pathogens of infectious diseases. The pathogens of air-borne infectious disease such as influenza tend to be responsive to humidity conditions. For example, absolute humidity and

temperature were found to affect influenza virus transmission and survival. Cold temperature and low relative humidity are favorable to the spread of influenza virus. Humidity change also affects the viruses of water-borne diseases. For example, the survival of water-borne viruses near water surface is limited due to the drying effect of surface water. Lastly, virus of vector-borne diseases may be impacted by humidity change (Lowen *et al*., 2007).

Wind is another key factor that affects the pathogens of air-borne diseases. Literature suggested a positive correlation between dust particle association/attachment and virus survival/transport. It has been reported that the presence of desert dust in the atmosphere during Asian dust storms (ADSs) is associated with increased concentration of cultivable bacteria, cultivable fungi, and fungal spores. The concentration of influenza A virus was significantly higher during the ADS days than normal days. Studies further suggested that the viruses of infectious diseases be transported across ocean by dust particles which may facilitate the transmission of viruses between distant hosts (Chen *et al*., 2010).

*Effect of Climate change on vectors and hosts*

Hosts refer to living animals or plants on or in which disease pathogens reside. Vectors are intermediate hosts and they carry and transmit pathogen to living organisms which become hosts. This review focuses on animal hosts, especially insects. The geographical locations and population changes of insect vectors are closely associated with the patterns and changes of climate. Thus, climate change may cause changes in range, period, and intensity of infectious diseases through its impacts on disease vectors (Harvell *et al*., 2002).

No disease or vector distribution can be fully understood in terms of climate only. The supply of suitable hosts, the effects of co-infection or immunological cross-protection, the presence of other insects competing for the same food sources or breeding sites as vectors (Davis *et al*., 1998), parasites and predators of vectors themselves, could have important effects. Climate change may affect the abundance or distribution of hosts or the competitors/predators/parasites of vectors and influence patterns of disease in ways that cannot be predicted from the direct effects of climate change alone (Harvell *et al*., 2002).

Equally, it has been argued that climate change-related disturbances of ecological relationships, driven perhaps by agricultural changes, deforestation, the construction of dams and loss of biodiversity, could give rise to new mixtures of different species, thereby exposing hosts to novel pathogens and vectors and causing the emergence of new diseases. A possible 'example in progress' is the re-emergence in the UK of *bovine* tuberculosis, for which the badger (Meles meles) is believed to be a carrier of the causative agent, Mycobacterium bovis. Farm landscape, such as the density of linear features like hedgerows and other is a risk factor for the disease, affecting the rate of contact between cattle and badger. Climate change will be a force for modifying future landscapes and habitats, with indirect and largely unpredictable effects on diseases (White *et al*., 1993).

*Effects on hosts:*

Mammalian cellular immunity can be suppressed following heightened exposure to ultraviolet B (UV-B) radiation - an expected outcome of stratospheric ozone depletion (Aucamp, 2003). In particular, there is depression of the number of T helper lymphocytes, the cells involved in the immune response to intracellular pathogens. In terms of animal disease, such pathogens include viruses, rickettsia (such as Cowdria and Anaplasma, the causative agents of heartwater and anaplasmosis) and some bacteria, such as Brucella, the organism causing brucellosis. Furthermore, increased UV-B exposure may diminish the host's response to certain vaccinations. Continued ozone depletion could possibly impact on certain animal diseases, but it should be borne in mind that the association of UV-B with immunity has only been investigated in humans and mice. Diurnal animals that live outdoors may be less susceptible to heightened UV-B exposure (De

Gruijl *et al*., 2003).

A second host-related effect worthy of consideration is genetic resistance to disease. Many animals have evolved a level of genetic resistance to some of the diseases to which they are commonly exposed. For example, wild mammals in Africa may be infected with trypanosomes, but rarely show signs of disease. Local Zebu cattle breeds, which have been in the continent for millennia, show some degree of trypanotolerance (resistance) whereas recently introduced European cattle breeds are highly susceptible to trypanosomiasis. In stark contrast, African mammals proved highly susceptible to rinderpest which swept through the continent in the late 19th century, and which they had not previously encountered. It seems unlikely that climate change will directly affect genetic or immunologic resistance to disease in livestock (Eisler *et al*., 2003).

However, significant shifts in disease distributions driven by climate change pose a greater threat than simply that of the exposure of new populations. Naïve populations may, in some cases, be particularly susceptible to the new diseases facing them. Certain diseases show a phenomenon called endemic stability. This occurs when the disease is less severe in younger than older individuals, when the infection is common or endemic and when there is lifelong immunity after infection. Under these conditions most infected individuals are young, and experience relatively mild disease. Counter-intuitively, as endemically stable infections become rarer, a higher proportion of cases are in older individuals (it takes longer, on average, to acquire infection) and the number of cases of severe disease rises. Certain tick-borne diseases of livestock in Africa, such as anaplasmosis, *Babesiosis* and cowdriosis, show a degree of endemic stability (Eisler *et al*., 2003). Effects on vectors: Much has already been written about the effects of climate change on invertebrate disease vectors. Indeed, this issue, especially the effects on mosquito vectors, has dominated the debate so far. Remember, though, that mosquitoes are less significant as vectors of animal disease than they are of human disease. Mosquitoes primarily, and secondarily lice, fleas and ticks, transmit a significant proportion of important human infections. By contrast, biting midges, brachyceran flies (e.g. tabanids, muscids, myiasis flies, hippoboscids), ticks and mosquitoes (and, in Africa, tsetse) all dominate as vectors of livestock disease. Therefore, a balanced debate on the effects of climate change on animal disease must consider a broad range of vectors (Anyamba *et al*., 2002).

There are several processes by which climate change might affect disease vectors. First, temperature and moisture frequently impose limits on their distribution. Often, low temperatures are limiting because of high winter mortality and a relatively slow rate of population recovery during warmer seasons. By contrast, high temperatures are limiting because they involve excessive moisture loss. Therefore, cooler regions which were previously too cold for certain vectors may begin to allow them to flourish with climate change. Warmer regions could become even warmer and yet remain permissive for vectors if there is also increased precipitation or humidity. Conversely, these regions may become less conducive to vectors if moisture levels remain unchanged or decrease, with concomitant increase in moisture- stress (Gagnon *et al*., 2002).

However, rainfall is not always agreeable for vectors. Excessive precipitation may have catastrophic impacts on mosquito population because strong rain may sweep away their breeding sites. On the contrary, drought in wet regions may decrease flow velocity in brooks and provide mosquitoes with more pools of stagnant water as breeding places (Kovats *et al*., 2003). The primary carrier of WNF is a type of mosquito named Culex, which usually breeds underground in the nasty water pools in city drains and catch basins. Drought allows for rotten organic materials to accumulate in those pools, forming favorite condition for Culex; heavy precipitation would wash the drains and water down the pools, limiting the spread of West Nile virus (Gagnon *et al*., 2002; Baylis *et al*., 1999).

*Effect of climate change on disease transmission*

Depending on the transmission route, disease transmission can be direct or indirect. Direct transmission refers to the transmission of a disease from one animal to another through droplet contact, direct physical contact, indirect physical contact, air-borne transmission, or fecal–oral transmission. Indirect transmission refers to the transmission of a disease to animal via another organism, a vector, or an intermediate host (Bouma, 2003).

Many studies have proved that climate variables and weather conditions may affect disease transmission, despite some uncertainty about the specific mechanisms. Rather than focusing on the disease transmission mechanisms, this section discusses the impacts that climate change may impose on the spreading of animal infectious diseases. This impact can be direct as changes in climate condition may alter disease transmission by directly influencing the viability of pathogens. It can be indirect if a change in the transmission routes resulted from the responding behaviors of animals and vectors/hosts to climate change (Bouma, 2003).

Temperature change alone, or together with other variable changes such as rainfall, may alter the transmission of diseases. Studies have reported an association between interannual variability in temperature and malaria transmission in the African highlands (Bouma, 2003). Hemorrhagic Fever with Renal Syndrome incidence closely correlates with meteorological factors that include temperature, rainfall, and humidity (Xiao *et al*., 2014). Wind and dust storms may also affect the transmission of infectious diseases. Wind can act as a transportation means for pathogen and virus of air-borne diseases. Pathogens can spread from endemic regions to other regions through interregional dust storms (Chen *et al*., 2010).

In other ways climate change can affect the transmission of infectious diseases through altering the contact patterns of animal–pathogen, animal–vector, or animal–host. Evidences showed that diseases transmitted by rodents sometimes increase during heavy rainfall and flooding events because of altered patterns of animal–pathogen–rodent contact (Bouma, 2003). For example, there have been reports on flood associated outbreaks of leptospirosis (Weil's diseases) in Central and South America and South Africa. The risk factors for leptospirosis for peri-urban population in low-income countries include flooding of open sewers and streets (Sarkar *et al*., 2002).

Climate variation plays an important role in shaping the patterns of human and other host activities and behaviors, such as seasonal occupation, migration, winter–summer lifestyles, and physical exercises these in turn can significantly influence the patterns of disease transmission (Kuhn *et al*., 2005). The seasonal prevalence patterns of influenza infection in Europe are believed to be related to peoples and animals spending longer hours indoor during winter. It was shown that within each wild fowl migratory flyway, the timing of H5N1 outbreaks and viral migrations are closely associated (Tian *et al*., 2015c).

Live poultry markets particularly in the holiday season serve as sources of human infected avian influenza and interacting with migratory birds may also contribute to the transmission of the virus. The elevated morbidity of gastroenteritis in temperate developed countries during summer months could be related to increased picnics and other outside-cooked meals. The re-emergence of kala-azar (visceral leishmaniasis) in the cities of the semi-arid northeastern region in Brazil in the early 1980s and 1990s was caused by the rural–urban migration of the subsistence farmers (Kuhn *et al*., 2005).

Climate change can harm animal immunity and susceptibility to disease, thereby affecting disease transmission. It may lead to ecosystem degradation, which will possibly bring pressure on agricultural productivity, causing issues such as crop failure, malnutrition, starvation, increased population displacement, and resource conflict. These pressures can contribute to increased animal susceptibility to infectious diseases (Hay *et al*., 2002).

*Indirect Impacts of Climate Change*

Specific studies describing the impact of climate change on livestock and wildlife diseases or pathogen emergence are not abundant. Factors such as landscape changes that remove portions of host populations ( example habitat alteration or destruction), alteration of host migration patterns or increased host density that are likely to influence disease emergence have been described ( Daszak *et al*., 2000).

Climate change is indirectly affecting the abundance and distribution of the competitors, predators and parasites of vectors themselves, thus influencing patterns of disease. It may also be that changes in ecosystems, driven by climate change and affect land-use, could give rise to new mixtures of species, thereby exposing hosts to novel pathogens and vectors and causing the emergence of new diseases (WHO, 1996). Changes in the frequency and distribution of diseases due to climate variability have been reported; however, estimating the real impact of climate change on livestock health over a long period still is a challenge (Van den Bossche, 2008).

It seems difficult to separate non-climatic factors from climatic factors. The best way of estimating a future impact of climate change is based on empirically observed relationships between climatic conditions and their effects on the biological processes that determine diseases transmission in space and time (Rogers and Randolph, 2006).

*Impacts of climate change on Food safety and Nutrition*

Climate already influences food safety within an agricultural system—prior to, during, and after the harvest, and during transport, storage, preparation, and consumption. Changes in climate factors, such as temperature, precipitation, and extreme weather are key drivers of pathogen introduction, food contamination, and food borne diseases, as well as changes in the level of exposure to specific contaminants and chemical residues for crops and livestock (Patz *et al*., 2008).

The impact of climate on food safety occurs through multiple pathways. Changes in air and water temperatures, weather-related changes, and extreme events can shift the seasonal and geographic occurrence of bacteria, viruses, pests, parasites, fungi, and other chemical contaminants (Zhan, 2012). For example: Higher temperatures can increase the number of pathogens already present on produce and seafood. Bacterial populations can increase during food storage which, depending on time and temperature, can also increase food spoilage rates (Cooper *et al*., 2015). Sea surface temperature is directly related to seafood exposure to pathogens (Walthall *et al*., 2012). Precipitation has been identified as a factor in the contamination of irrigation water and produce which has been linked to foodborne illness outbreaks (Bebber, 2015).

*Impacts on behavior, distribution and movements of wildlife*

Climate change will affect wildlife habitats and food sources, which could result in changes in wildlife behavior and feeding patterns in response to the new conditions. For example, the Daubenton's bat, 2% of which are sero-positive for European bat lyssavirus is increasing in abundance across Great Britain (GB) and feeds on insects over water. The effect of climate change (e.g. hot, dry summers interspersed with periods of extreme flooding) on the behavior of this bat is not known (Battersby, 2005).

Competition between wildlife species within an ecosystem often limits the abundance and / or distribution of one or more species. For example, global decline in amphibian populations is already occurring as a result of habitat loss, infection by a chytridiomycete fungus and climate change, with some species now extinct in Latin America (Lips *et al*., 2005). Climate change will affect animal migration and distribution. In the long term, could wild bird movements be reduced by climate change? This would depend on the availability of food and the day length for finding food in the breeding grounds during winter. Climate change could also result in wild bird breeding ranges shifting northwards from Mediterranean regions into GB, as occurred with the little egret in the

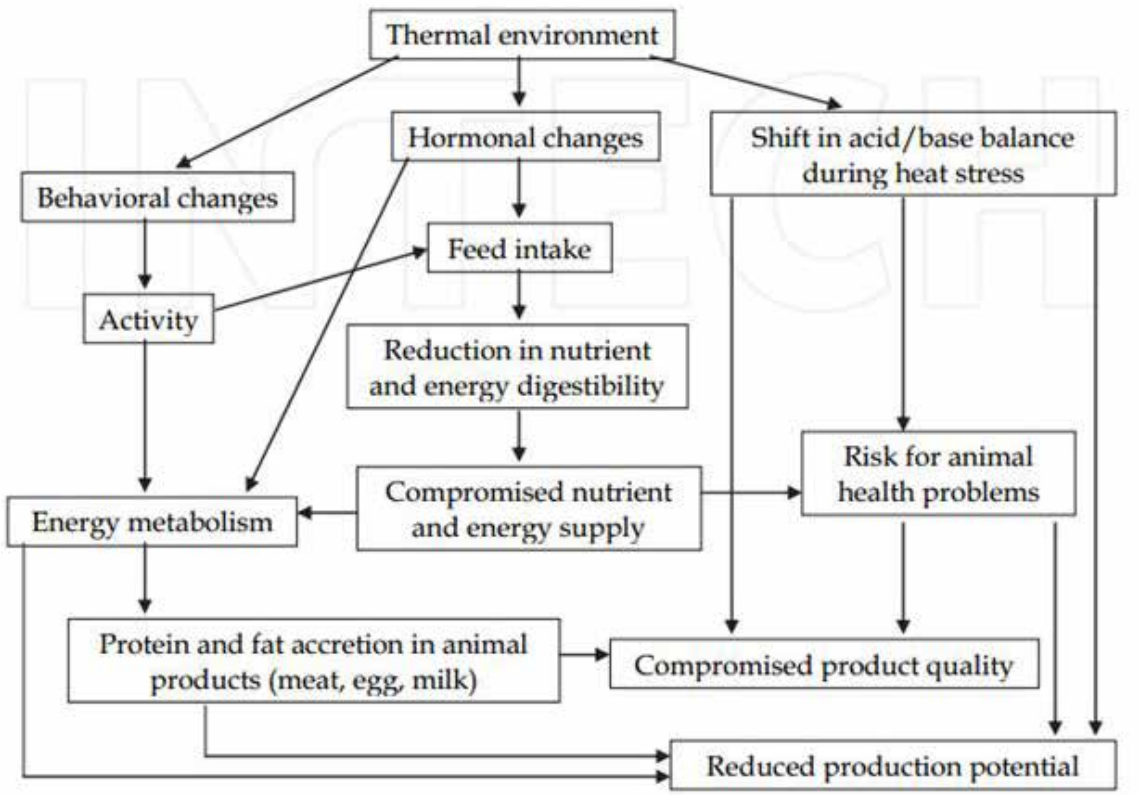
mid-1990s and more recently with the cattle egret. Little egrets, in particular, are vulnerable to long periods of cold that may be diminishing as a result of climate change. The serotine bat is currently restricted to southern England (Battersby, 2005) and climate change might facilitate a northwards expansion of its range. Warming trends in Fenno-Scandinavia have allowed badgers to extend their distribution 100 km northwards in Finland since the mid-1940s and badgers now occur as far north as the Arctic Circle (Root *et al*., 2007).

*Impact of Climate Change on animal Production*

In IPCC Third Assessment Report (2001) there is a section devoted that the vulnerability of animal production, warming those animal production facilities will be affected both directly and indirectly by climate change. The direct effects include the interchange of heat between the animal and its environment, associated with temperature, humidity, wind spread and thermal production. These are factors that influence animal performance (growth, milk and wool production, reproduction), as well as animal health and welfare (IPCC, 2001).

The indirect effects include the influence of climate on the quantity and quality of fodder crops and grains, and severity and distribution of diseases and parasites. When the magnitudes (intensity and duration) of adverse climate conditions exceed certain limits, with little or no possibility of recovery, animal, functions are adversely affected as a result of stress.

Genetic variation, the stage in the life cycle and nutritional status also influence their vulnerability and resilience to environmental stress. For example milk production from dairy cattle and conception rates can fall dramatically, and vulnerable animals may die as a result of extreme events (IPCC, 2007).




*Source: (Lacetera et al., 2002).*

**Figure 2:** Effects of inconvenient thermal environment on the production potential and product quality of livestock.

*Climate Change and Zoonotic Diseases*

Climate and environmental change could be associated with many emerging and re- emerging zoonoses that can be transmitted from animals to humans and from humans to animals. An estimated 75% of emerging infectious diseases in humans have evolved from exposure to zoonotic pathogens (IPCC, 2003). Climate change may cause increased environmental survival of pathogens. It may also cause changes in prevalence of pathogens in animal reservoirs, and changes in host–parasite ecology. Climate change could also shift boundaries for spatial distributions, host–parasite assemblages, and demographic rates. Life-cycle phenologies, associations within ecosystems, virulence, and patterns of infection and disease may also be caused by climate change (Polley, 2009).

Climatic variation also creates new ecological niches for vectors. It may also influence the epidemiology of zoonotic diseases, and causes changes in reservoir and vector dynamics (Cutler *et al*., 2010). Zoonotic infections are on the rise. The infection poses significant additional threats to human health. The threat gets worsened due to the complexity of the different organisms involved. In low□ income countries, zoonoses are estimated to be responsible for one-fifths of the infectious diseases in human (Heymann, 2008).

Ethiopia was identified as a "hotspot" for zoonotic disease events. The country ranked number one hotspot for leptospirosis, the fourth largest hotspot for Q fever and Trypanosomosis, and the tenth for tuberculosis. Much of the burden of zoonosis (68%) is distributed among only 13 countries. Ethiopia has the 4th highest burden caused by zoonosis. These ranks indicate an already existing burden of zoonotic disease in the country. The burden has the potential to be exacerbated by the effects of climate change (Grace, 2012).

## Current Status and Future Prespective Effect of Climate Change in Ethiopia

Africa is a vast continent with a wide variety of climate regimes. The continent is predominantly tropical, hot and dry but there are small regions of temperate, rather cool climate in the extreme north and south and at higher altitudes. Nevertheless, observations show that the African continent is warmer than 20 years ago, with an average rate of warming of about 0.05°C per decade. Moreover, the African climate has, during the 20th Century, experienced wetter and drier intervals than during previous centuries. Projections for the rates of change in temperature and precipitation for the 21st Century vary but, irrespective of this uncertainty, future annual warming is expected to be highest in the interior of the semi-arid regions of Saharan and central southern Africa, resulting in desertification because people living in Africa are hardest hit. So that large effects of climate with respective animal disease will be expected (IPCC, 2001).

From the tropical countries of East Africa; Ethiopia is considered a center of diversity for animal genetic resources in general and to cattle in particular. Indigenous cattle breeds in Ethiopia are a valuable source of genetic material because of their adaptation to harsh climatic conditions, their ability to better utilize the limited and poor quality feed resources and to their tolerance a range of diseases found in these regions. Despite the significant contribution of cattle to the country, little attention is given to identify, characterize and conserve the diversity of the various classes of livestock (Zewdu, 2010).

Climate change is of critical importance to Ethiopia; mainly due to changes in the climate Ethiopia has faced recurrent droughts across its different parts. The mean annual temperature has, for example, increased by 1.3°C between the years 1960 and 2006. This is estimated to be an average rate of 0.28°C increase in temperature per decade (Conway and Schipper, 2011). This change is currently adversely impacting the health and lives of people and animal around the country. This is particularly true in low-income countries. It affects social and environmental determinants of health – clean air, safe drinking water, food security and shelter. The two most mentioned emerging and re-emerging animal diseases in

a recent OIE survey are Bluetongue and Rift Valley fever (McSweeney *et al*., 2008).

Climate models suggest that Ethiopia will see a further warming of 0.7°C and 2.3°C by the 2020s and between 1.4°C and 2.9°C by the 2050s (World Bank, 2008). The current population (over 87 million) is growing annually by 2.6% and is expected to be more than double by 2050 (FDRE, 2008). The country is extremely vulnerable to the impacts of climate change. The impact may potentially hold back economic progress or reverse the gains made in development, and thus exacerbates social and economic challenges due to expansion of both human and animal diseases (FDRE, 2008).

Animals in the afar regional state already suffer from the burden of endemic and emerging animal diseases which can be linked to the changing climate and the extreme weather conditions. Cold-blooded vectors are sensitive to direct effects of climate such as temperature, rain fall patterns and wind. Rising temperature influence the production and maturity rate of infective agents as well as the survival rate of the vector organisms, thereby further influencing disease transmission (IPCC, 2007). Climate also affects their distribution and abundance through its effects on host plants and animals (WHO, 2003).

Changes in frequency and severity of extreme climate events have significant consequences on food production and food security (IPCC, 2007). In the future, the investigators stated that about 1.3 billion poor people, at least 90% of them, would be located in Asia and sub Saharan Africa, and climate change will have major impacts on more than 600 million livestock dependent people (Thornton *et al*., 2002).Climate change could be particularly damaging to countries which are dependent on rain fed agriculture and are under heavy pressure from food insecurity and often famine caused by natural disasters (Deressa *et al*., 2007).

Climate change is predicted to reduce the gross domestic product (GDP) growth of the country by between 0.5 and 2.5% each year.

Climate change has the potential to hold back economic progress. Worse is that it can even reverse the gains made in development and exacerbate social and economic problems in the country.

*Economic Importance of Climate Change*

Animal diseases due to climate change generate a wide range of biophysical and socio-economic impacts that may be both direct and indirect, and may vary from localized to global (Perry and Sones, 2009). The direct effect of climate change as a result of increased ambient temperature and concurrent changes in heat exchanges causes heat stress which influences growth, reproduction performance, milk production, wool production, animal health and welfare (Walter *et al*., 2010). Mainly the economic impacts of diseases are increasingly difficult to quantify, largely because of the complexity of the effects that they may have, but they may be enormous: the total costs of foot-and-mouth disease in the UK may have amounted to $18–25 billion between 1999 and 2002 (Bio-Era, 2008).

Changes in frequency and severity of extreme climate events have also significant consequences on food production and food security (IPCC, 2007). In the future, the investigators stated that about 1.3 billion poor people at least 90% of them would be located in Asia and sub Saharan Africa including Ethiopia, and climate change will have major impacts on more than 600 million livestock dependent peoples (Thornton *et al*., 2002). This climatic change could be particularly damaging to countries which are dependent on rain fed agriculture and are under heavy pressure from food insecurity and often famine caused by natural disasters (Deressa *et al*., 2007).

Additionally, heat related mortality and morbidity would increase. Climate change is also expected to increase the risks of drought and floods that occur with El Niño in the future and this could result in serious high mortality of livestock due to drought resulting in pasture shortage and water scarcity which will aggravate the existing conflicts on natural resources and food insecurity in the region. Similarly El Niño may result in diseases outbreaks related to flooding that result in high economic loss in the

country (Van den Bossche, 2008).

## Conclusion and Recommendations

In conclusion, the livestock sector globally is highly dynamic. In developing countries, it is evolving in response to rapidly increasing demand for livestock products. In developed countries, demand for livestock products is stagnating. This livestock production system can be affected due to different factors from this; global climate change is a common phenomenon today. It has been proven that the change affect the emergence and spread of infectious diseases. This applies to both climate changes as a whole, as well as individual factors such as temperature, rainfall, humidity and others. These changes may directly impact the pathogen, and indirectly the vectors of these pathogens. They can also affect the resistance of humans and animals and disease transmission mechanisms. In addition to this climate change can also induce its effects on the nutrition, movement and distribution of both domestic and wild animal then the association between the emergence of infectious disease outbreaks and global climate change can be seen. Even if there is a substantial scientific literature on the effects of climate change on health and disease, there is a strong focus on human health and vector- borne disease. By contrast, the effects of climate change on animal or non-vector-borne disease has received comparatively little attention. Therefore, awareness creation about its effect on animal health is an important means of reducing its impacts on occurrence of animal diseases.

Based on the above conclusion, the following recommendations are forwarded:

- Livestock keepers could be made more aware of climate change and variability so surveillance systems should be established or improved.
- More research should be needed in areas were knowledge about effect of climate on animal health is lacking.
- Increased inter-sector collaboration and actions, nationally and internationally in relation to climate change is needed.
- Fast and coordinated action is needed to secure high veterinary and food safety standards.

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**AFRICAN UNION - INTERAFRICAN B*UREA*U FOR ANIMAL RESOURCES (AU-IBAR)**

Bulletin of Animal Health and Production in Africa
Guide for Preparation of Papers
Notes to Authors

The Editor in Chief
March 2018

**Aims and scope**

The Bulletin of Animal Health and Production in Africa (BAHPA) of the African Union Interafrican B*ureau* for Animal Resources (AU-IBAR) is a scientific journal which publishes articles on research relevant to animal health and production including wildlife and fisheries contributing to the human wellbeing, food security, poverty alleviation and sustainable development in Africa. The bulletin disseminates technical recommendations on animal health and production to stakeholders, including policy makers, researchers and scientists in member states. The Bulletin is the African voice on animal resources issues specific to Africa.

The Bulletin of Animal Health and Production publishes articles on original research on all aspects of animal health and production, biotechnology and socio-economic disciplines that may lead to the improvement animal resources. Readers can expect a range of papers covering well-structured field studies, manipulative experiments, analytical and modeling studies of the animal resources industry in Africa and to better utilization of animal resources.

The BAHPA encourages submission of papers on all major themes of animal health and production, wildlife management and conservation, including:

- Veterinary microbiology, epidemiology
- Marketing, economics
- Infectious and non infectious disease
- Parasitology
- Genetic improvement and biotechnology
- Animal production, nutrition and welfare
- Science and policy in animal health and production
- Beekeeping and honey bees
- Ecology and climate change impacts on animal resources in Africa
- wildlife management
- Fisheries and aquaculture development
- Food safety and food hygiene
- One health
- Emerging and re-emerging issues in animal resources
- Biosecurity
- Animal resources trade and value chain
- Socio economics and economics of animal resources development

**Language**

The language of submission should be either in U.K. English or Standard French. The abstract is translated to the other three languages of the African Union (Arabic, English, French and Portuguese ), by the editors, after acceptance. Full articles submitted in French will also be published in English.

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Authors are invited to submit electronically their manuscripts via attachment only at bahpa@au-ibar.org in a secured PDF and word format. Manuscript can be sent by post in case of unavailability of internet services (authors should be aware that in this case it will take longer time to be published).

Authors submitting articles to the BAHPA must follow the guidelines in this document. Submissions that deviate from these guidelines will be returned to the corresponding authors for changes and compliance.

To be considered for publication in the BAHPA, any given manuscript must satisfy the following criteria:

- Originality. BAHPA does not accept manuscripts that have already been published elsewhere. However, studies that replicate results that are already in the literature may be considered for publication, as the independent confirmation of results can often be valuable, as can the presentation of a new dataset.
- Audience. Manuscripts submitted must be of broad interest to animal health and production professionals in general, they must capture and hold readers' attention.
- Usefulness. Manuscripts submitted must help researchers, trainers, educators and policy makers in all regions of Africa improve their effectiveness.
- Rigorous methodology. Manuscripts submitted must be based on valid and reliable information, documentation or sound concepts, empirically, logically and theoretically supported.
- Well written to ensure clear and effective presentation of the work and key findings. The BAHPA editorial staff does not copyedit the text of accepted manuscripts, it is therefore important for the work, as presented, to be intelligible. Perfect, stylish language is not essential but it must be clear and unambiguous. If the language of a paper is not clear, Academic Editors should recommend that authors seek independent editorial help before submission of a revision. Poor presentation and language is a justifiable reason for rejection.
- Experiments, statistics, and other analyses performed are described in sufficient detail. The research must have been performed to a technical standard to allow robust conclusions to be drawn from the data. Methods and reagents must also be described in sufficient detail so that another researcher is able to reproduce the experiments described.
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- The research meets all applicable standards for the ethics of experimentation and research integrity. Research to be published must have been conducted to the highest ethical standards. A brief description of the most common of these is described in our Editorial and Publishing Policies.
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**Types of contribution**

Full papers providing accounts of original work: Research containing significant new findings. The material presented should be original and not have been published elsewhere, except in a preliminary form. Papers will be reviewed by three referees familiar with the subject matter of the paper.

*Short Communications:* are intended to provide quick publication of highly relevant and interesting information. Manuscripts will be peer reviewed by two reviewers and the Editor.

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*Letters to the Editor:* the bulletin welcomes letters to the editor. The purpose of Letters to the Editor is to provide a forum for positive and constructive views on articles and matters published in the bulletin. Letters to the Editor must not exceed 300 words. Letters to the editors include technical reports from countries or projects.

*Key notes and special calls:* The editor will, from time, invite selected key figures in the field of animal health and production for key notes on specific topics. Book Reviews: are accepted and should provide an overview of the work's contents and a critique of the work's value. Book reviews should be limited to 1000 words.

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Obituary articles to honor prominent African scientists that have made significant contribution to animal resources research and development

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Full papers of original research

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1. On cover page of the manuscript, the following should be clearly written/inserted: the corresponding author, name of the institution, , title of the manuscript, names of the authors, the addresses of the authors and the e-mail address of the corresponding author. The corresponding author should ensure that all the other authors consent to their names being included. The consent should be sent directly by co-authors to the editor via email.
2. Each original article should be divided into Abstract and Keywords, Introduction, Materials and Methods, Results, Discussion, conclusion, Acknowledgments and References. A textbox containing a public brief on the study for the benefit of policy makers should also be provided. This textbox will not be included in the published article but will be compiled and published in a separate edition at the end of the year.
3. Title, which should be concise, preferably not more than 15 words long, followed by the author(s) name(s) and institution(s) to which work should be attributed and address for correspondence, if different.
4. The Abstract should not be longer than 300 words giving a synopsis of the work and should contain the objectives, briefs description of materials and methods, highlights of significant results, conclusions and recommendations. Up to six keywords should be provided..
5. The Introduction should contain the problem statement, the hypothesis and the objective of the work and cite recent important work undertaken by others.
6. Materials and Methods should describe materials, methods, apparatus, experimental procedure and statistical methods (experimental design, data collection and data analysis) in sufficient detail to allow other authors to reproduce the results. This part may have subheadings. The experimental methods and treatments applied shall conform to the most recent guidelines on the animal's treatment and care. For manuscripts that report complex statistics, the Editor recommends statistical consultation (or at least expertise); a biostatistician may review such manuscripts during the review process. Cite only textbooks and published article references to support your choices of tests. Indicate any statistics software used.
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8. Discussion of significance should be focused on in the interpretation of results. Subheadings are not accepted in this section.
9. Acknowledgements. Where necessary acknowledgements of grants and technical assistance should be included under this heading. . Please also include any potential conflict of interests if appropriate. Suppliers of materials should be named and their location (town, state/county, country) included.
10. State the conclusions, and any implications that may be drawn from the study.

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**Sequence of Preparation**

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- *Books:* Durbin R, Eddy SR, Krogh A, Mitchison G, 1999. Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids. London, Cambridge University Press.

- *Chapter in a Book:* Leach J, 1993. Impacts of the Zebra Mussel (Dreissena polymorpha) on water quality and fish spawning reefs of Western Lake Erie. In Zebra Mussels: Biology, Impacts and Control, Eds., Nalepa T, Schloesser D, Ann Arbor, MI: Lewis Publishers, pp: 381-397.
- *Reports:* Makarewicz JC, Lewis T, Bertram P, 1995. Epilimnetic phytoplankton and zooplankton biomass and species composition in Lake Michigan, 1983-1992. US EPA Great Lakes National Program, Chicago, IL. EPA 905-R-95-009.
- *Conference Proceedings:* Stock A, 2004. Signal Transduction in Bacteria. In the Proceedings of the 2004 Markey Scholars Conference, pp: 80-89.
- *Thesis:* Strunk JL, 1991. The extraction of mercury from sediment and the geochemical partitioning of mercury in sediments from Lake Superior, Unpublished PhD thesis, Michigan State University, East Lansing, MI.
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